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EDITORIAL.

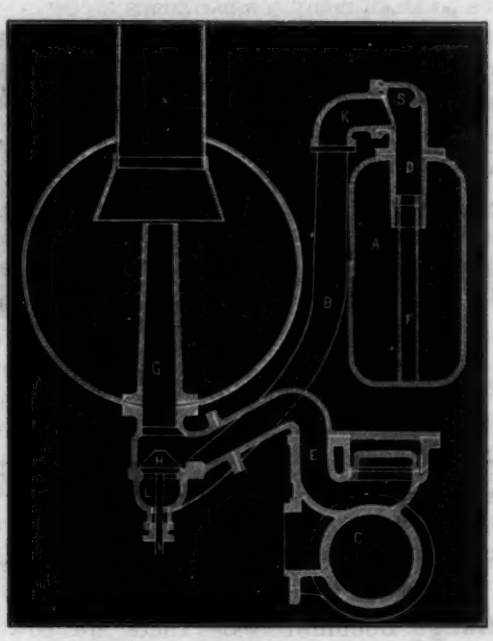
ITEMS AND NOVELTIES.

Lock-Nut and Washer.—At the last meeting of the Institute there was exhibited and described a lock-nut and washer, the invention of Mr. U. B. Vidal. The improvement claimed consists in the use of a nut, the inner face of which is furnished with one or more diagonal slots. The washer is of lead, and when in place a key is driven home into the slot on the face of the nut, which forms a counter-slot in the washer, and by this means firmly attaches the bolt.

The main purpose of the invention seems to be to provide a permanent joint for securing the fish-plates at the ends or joints of rails. The difficulty to be overcome is the effect of the excessive vibration given to the joints by the passage of trains, which being communicated to the bolts, rapidly loosens them. The inventor claims that the inelastic nature of the leaden washer obviates this source of evil, by absorbing these vibrations or failing to transmit

them to the nuts. Instead of keying, other methods of attachment are suggested as equally efficacious.

Tank Locomotive with Condensation.—In the figure represented below, the exhaust steam escapes from the cylinder through the pipe E, thence through the blast-pipe G to the chimney in the usual way; but at the base of the blast-pipe is fitted a double-faced conical valve under the control of the engineer by a system of levers and rods connected to the valve-stem J. A chamber L beneath this valve communicates with the condenser A through the connected pipes B, K and D; in the lower end of the latter, the cold water pipe F terminates and at its upper end the valve S is hinged, opening towards the condenser.



When it is desired to suppress the blast the valve H is moved to its upper seat 1, and cold water is ejected through the pipe F into D from which it descends through the annular space around the top end of F into A, whence it may be forced into the boiler or thrown overboard.

A distance of 1000 metres may be passed over before it will be necessary to empty the condenser of water. Should the boiler be

fed therefrom the action of the condenser might be made continuous, but as the want of blast in the chimney would retard the generation of steam, the continued advantage of vacuum and suppression of blast could not be obtained.

This apparatus is, however, designed for temporary action, as while passing thoroughfares, tunnels, bridges and the like.—*The Praktische Machinen-Constructeur*, Leipzig, 1870, p. 274. J. H. C.

The Multi-Chambered Boiler.—The engraving annexed represents an elevation of the boiler, with part of the casing removed for the purpose of exhibiting the interior. B is the fire-piace, D the stoke-hole, EE the chambers, constructed of the best wrought iron, FF shows the manner in which all the chambers are bolted together so as to form a boiler of many compartments.

"There are fillets of iron, which keep the individual compartments at a proper distance from each other; and the spaces which these fillets leave are the flues of the boiler, through which the flames ascend as shown at H H H. All these compartments are connected at the bottom for the purpose of keeping the water in each at the proper level; and at the top the steam is conveyed from each by as many pipes as there are chambers, into the steam feed pipe, by which steam is conveyed to the engines. By this arrangement, the only parts of the boiler which can be dreaded are the sides; but good ties will keep them together. And as to the bottom end, and top of the boiler, which are composed of the edges of these compartments, if one part is burnt out or hurt it is only that individual compartment which can burst, and its power of doing mischief is not worth notice."—*Walter Hancock's Steam Carriage Boiler, Mech. Mag., Feb.*, 1833, p. 79. J. H. C.

Narrow-Gauge Locomotives.—There are now being constructed at the Baldwin Locomotive Works (Messrs. Baird & Co.) several narrow gauge locomotives for the Denver and Rio Grande Railroad (3 feet gauge), As signalizing the "new departure" in railway practice, considerable interest naturally attaches to the fact.

One of the engines is already finished. It is six-wheeled, four of the wheels 40 inches in diameter, being coupled as drivers, and one pair of leading wheels in front having a swing bolster and radius bar, forming what is known as a "pony truck." The general plan

is similar to that of ordinary full-gauge locomotives. The cylinders are outside, and placed horizontally, and are 9 inches in diameter by 16 inches stroke. Its total weight, in running order, is 25,300 pounds, of which 20,500 pounds are carried on the four driving wheels, and so available for adhesion. A four-wheeled tender, having a water capacity of five hundred gallons and a coal capacity of about 1½ tons, is attached.

The proportion of driving wheels relatively to the stroke of piston admits of a speed of thirty to forty miles an hour with equal facility as on the full gauge.

As an evidence of the interest now prevailing on the narrow gauge question, it may be stated that contracts have been received to furnish locomotives for several narrow-gauge roads, both in this country and Canada.

A huge Electro-Magnet.—Wallace & Sons, of Ansonia, Connecticut, have just delivered to the Stevens Institute of Technology a magnet which weighs in all about 1600 pounds. The coils are wound on eight brass spools, each 9½ inches high by 11½ inches external diameter. About 400 pounds of copper wire, ⅛-inch thick, are wound on these spools, which are of course split and filled in with vulcanite. The cores are hollow, and 6 inches in diameter by 3 feet 8 inches in length. The lifting force of this magnet is estimated at between 30 and 50 tons. It will be five times as powerful as the one used by Faraday and Tyndall in their famous researches.

Marine Boiler Fittings.—The English Board of Trade has issued a circular to surveyors whose duty it is to see that the provisions of the Merchant Shipping Act are observed, from which it seems to be the intention of this Board that henceforth the employment of cast-iron pipes and other fittings in boilers on board steamships shall be prohibited, and that the use of copper or brass must be substituted for such fittings and pipes. Our cotemporary *Engineering* strenuously protests against the order, which it characterizes as an obnoxious and high-handed interference with manufacturing industry.

Testing Silver Plating.*—Dr. Böttger states that a cold solution of bichromate of potassa in nitric acid is an excellent test for the genuineness of a silver-plated surface. It is first necessary to thoroughly remove from it all dirt, grease or varnish, by washing with strong alcohol. A drop of the liquid is then applied, and at

* Dingler's Polytechnic Journal.

once washed off with water, when, if pure silver is present, a blood-red stain will be left where it had been applied. A number of other metals are stained, but none are so sensitive or so easily to be recognized as that of the chromate of silver.

Coal Supply of England.—The Royal Commission appointed some years since to examine into the condition and future prospects of the coal supply has, according to the *Times*, nearly completed its labors. The report is said to contain a demonstration of the fact that, allowing for an annual increase in demand, enough of econonomically available coal exists in the British Isles to meet the wants of consumers from 800 to 1000 years to come.

The appearance of the report will be looked for with interest by many who have imbibed the widespread popular impression, that the available supply of this all-important product was rapidly being exhausted by the long continued and constantly increasing drains upon the mines.

Decoration of Metals.—Dr. Puscher recommends a solution composed of a mixture of 3 parts of hyposulphite of soda and 1 of acetate of lead, for the purpose of decorating metallic surfaces. When heated to about 100° C., this solution deposits a layer of sulphide of lead upon any metallic surface in contact with it—the effect of the peculiar color of the metal beneath being to produce a great variety of tint.

Gun-Cotton is now manufactured in England to an amount exceeding 100 tons per annum. The cotton fibre is reduced to a pulp, as in paper making, in which condition the excess of acids is readily removed. The pulp is compressed into disks, under a pressure of 18 tons to the inch, and then dried. These disks are $\frac{1}{8}$-inch to 7 inches in diameter, and $\frac{1}{2}$-inch to 2 inches thick. In the open air this compressed cotton burns intensely, but without explosion; but when properly exploded under close confinement, its strength is from 2 to 5 times that of the same weight of gun-powder. If accidentally wetted, this form of gun-cotton can be re-dried by exposure to the sun, or even by a gentle heat, without risk of explosion or deterioration.

Petroleum Production.—A review of the status of the petroleum trade, according to a cotemporary, furnishes the fact that at the close of the year 1870 there were in the Pennsylvania oil region about three thousand productive wells. The production of the United States and Canada during the year is estimated to have

reached the enormous figure of six million five hundred thousand barrels, an increase of two millions of barrels over the product of 1869.

Casting under Pressure.—The casting of car wheels under pressure, according to a recent patent, has for some time been in progress at the Fairhaven (Mass.) Iron Works. It is claimed that the product is more compact, homogeneous, and free from air bubbles.

A New School of Mechanical Engineering.—Many of our readers will be interested to learn that the want so long felt in this country, of a means of thorough scientific training for those intending to pursue the profession of the mechanical engineer, is at last supplied in a very thorough manner. Among our advertisements will be found that of the Stevens Institute of Technology, which will open its first session on the 20th of next month.

This institution, with an aggregate endowment (including accrued interest) of $750,000, a Faculty consisting of a President and seven Professors, and laboratories, cabinets of instruments and models of machinery, as well as workshops supplied with machine tools, and every other appliance of instruction, in a condition of completeness without a parallel in this country or abroad, affords an opportunity to the student of Mechanical Engineering to render himself thoroughly acquainted with the science and practice of his profession, such as will no doubt before long produce a marked impression on this and the countless dependent branches of industry.

We give herewith a front view of the Institute building, and in subsequent numbers will publish some accounts of its arrangements and collections, which involve much of novelty and interest.

Patent Law Reform.—There is herewith presented a copy of a series of resolutions upon the proposed changes in the British Patent Law. Most of the resolutions, we believe, will meet with the hearty concurrence of all having business in connection with patents; while the reforms, if made, will certainly not lessen the contrast between the thoroughness and convenience of the British Patent system and the imperfection of our own.

At a meeting of the London Patent Agents, held on the 4th inst., to consider the proposed changes in the patent laws, George Haseltine, M. A., in the chair, the following resolutions were adopted:

First—That the chief defects of the patent laws have arisen from a want of appreciation of the *natural* rights of inventors to the sole

FRONT VIEW.

use of their inventions, an unreserved recognition of which rights must pervade every equitable patent system, and the true aim of patent legislation is to harmonise these individual rights with the material interests of the state.

Second—That the grant of patents to mere "*first importers*" is an injustice to inventors, an injury to society, as it induces the "pirating" of inventions, and the reason for these grants no longer existing, legislation should confine the issue of patents to actual inventors and their representatives.

Third—That, in view of the benefits inventors confer on the public, and the expenses incident to the completion and introduction of new inventions, a patent for fourteen years is an inadequate compensation, and we deem it expedient to grant patents for a period of twenty-one years without the privilege of extension.

Fourth—That the patent laws impose *penalties* upon inventors in the form of excessive fees, which justice and public policy demand should be reduced to the amount requisite to defray the expenses of an efficient administration of a simple patent system, and fees of ten pounds for the entire term—now one hundred and seventy-five pounds—would yield more than sufficient for the purpose.

Fifth—That the defects of the present practice should be remedied by the adoption of equitable "regulations," and the introduction of the system of granting patents, at the risk of the applicants, without any official supervision of the specification or preliminary investigation of the merits of the invention.

Sixth—That the rights of patentees should be determined by a competent tribunal, excluding all technical objections to the validity of the patent, and we deem it expedient to dispense with jurors and "scientific experts" in patent suits.

Seventh—That these resolutions, signed by the Chairman, be forwarded to the Parliamentary "Select Committee on Letters Patent," and such other publicity be given them as he may deem conducive to the success of a liberal measure of patent legislation.

Crystallization of Carbonate of Lime.—It is well known that the carbonate of lime occurs in nature in two distinct crystalline forms, or two distinct mineral species, which are known as Calcite and Aragonite. The researches of Rose, published some years ago, proved that the temperature at which the carbonate was deposited from solution, affected the character of the product—the Calcite form being deposited from cold, and the Aragonite from hot

solution. A recent investigation by H. Credner has, it seems, added considerably to the list of causes which may produce this difference. As his experiments explain themselves, we will merely state his results.

A pure, cold solution of the double carbonate of lime deposits Calcite; the addition of some silicate of potassa produced the same product (as did also silicate of soda and a mixture of the two silicates), the crystals being of great clearness, and rich in surfaces. A solution of the carbonate of lime and some strontia, when made together in carbonic acid, deposited without exception the prismatic Aragonite; where the strontia solution was brought into that of the lime, rhombohedral crystals of the Calcite made their appearance along with the Aragonite, and the formation of Calcite increased as the quantity of the strontia was diminished.

An addition of Gypsum (sulphate of lime) to the lime solution, gave rise to the production of Aragonite. Additions of salts of lead produce the same result, though subject to the same regular variation as in the case of the presence of strontia.

The results of these experiments are of the greatest importance to the mineralogist, for they prove that one and the same substance can be made to originate entirely different mineral species through the impulse derived by certain foreign additions to its solutions; and also that the state of saturation and the temperature of the deposition are not the only causes of dimorphism.

We gain an insight, too, by these interesting results into the probable cause of the frequent association of the minerals in question with others. For example, the frequent association of Calcite with minerals rich in alkaline silicate, as with Apophyllite and other Zeolites, and of Aragonite with Gypsum.

Origin of Hail.—Prof. Reinsch* announces that it is impossible, in the present state of our knowledge, to proclaim a theory which shall satisfactorily explain the origin of this meteorological phenomenon.

Though it may be safely asserted that the conditions originating it are different from those producing the deposition of rain or snow, or that these conditions are more intense in character, yet a microscopic examination of hail proves that the conditions originating it are by no means always the same; for the structure of the product is rarely the same. He mentions the curious fact that in some

* Pogg. Ann., CCXVIII, 623.

hail which he examined beneath the microscope, there was found at the centres of the stones a spherical globule, which proved to be air. When these globule were nearly freed by the melting of their icy confinements, they burst the last portions of the shell with energy, and, expanding, occupied in a bubble form a space more than fifty times greater than when confined; showing that they had been subject to a pressure equivalent to more than fifty atmospheres. Cold may possibly have had some part in this diminution of volume; but the temperature necessary to produce so great a reduction in volume must have reached—214° C. at the point where the hail was formed—if cold had been the only cause in play. Whatever explanation we assign to this interesting observation, it must certainly be regarded as the most unexpected one which has yet appeared in the study of this puzzling phenomenon. Prof. R. recommends the diligent use of the microscope as the only means of solving the problem of the history of hail.

Announcement of the Prussian Association, for the promotion of Industry, at Berlin.—The programme of the Society which has appeared contains the following announcement, which may prove of interest.

The gold medal of the Association, or the money value thereof, and in addition the sum of $750, will be given to the author who gives a reliable and readily executed method of determining the quantity, as well as the various compounds met with in commercial aniline (aniline oil), and who determines also the influence which the diversity of these compounds exerts upon the manufacture and upon the yield of fuchsine. It is also desired that an investigation should be made into the conditions under which aniline yields the greatest quantity of coloring matter. The silver medal, or money value thereof, and in addition $215, is offered for the best preparation of an opaque enamel on gold, silver, copper or bronze. A donation of $187 to the author of the most critical essay on Cements in their relation to the wants of Industry. And, amongst other donations, their silver medal, or its money value, and $375, to the inventor of a yellow-colored solder which possesses the qualities of ordinary tinman's solder, by which brass and similar alloys may be united without allowing the joints to be visible.

A Barometer without Mercury.—A Heller has recently published a description of an instrument of this kind, in which the principle of the communicating tube is avoided, and the same result

is reached by ascertaining by a simple process the specific gravity of the air, and calculating from this the pressure at any given time and place.

The instrument consists of a balance-beam, with two equal weights screwed to its ends; these weights differ in volume, one of them being a hollow globe; the other a solid cylinder. At one end of the beam, and attached perpendicular to its axis, is a mirror; and at a little distance from this is fixed a telescope with vertical scale. On looking into the telescope, the image of the scale is seen on the mirror. Any variation in the pressure of the air will cause the balance to tilt, and the angle through which the beam has moved is readily determined. The oscillations of the beam for ordinary variations of pressure will be very small, but by the plan of reading the oscillations with the mirrors, a much greater precision is obtained than is possible by reading from the mercurial barometer.

By calculation, it appears, according to the author, that for 1 millimetre difference in the level of the mercury column, the beam end will move through a vertical distance on the scale of from 4 to 5 millimetres. In addition to the greater precision in reading small oscillations, other advantages are claimed.

In the ordinary barometer a large weight of mercury must be moved, implying a considerable friction against the walls of the tube, which must be overcome; if the variations of pressure are rapid, the inertia of the metal will not permit it to follow them with sufficient promptness to indicate with accuracy the maximum and minimum pressures. The influence of the slight quantity of mercury vapor always present above the column on the capillary depression, and the action of the included air, which increases with time, are beyond calculation and beyond remedy.

The ordinary barometer, again, presupposes a liquid, the specific gravity of which is accurately known. This is, however, not the case; for chemically pure mercury is difficult to obtain, and when obtained it rapidly changes by partial oxidation, thus materially affecting both the adhesion and capillary depression.

These, and analogous imperfections, which appear to be inseparable from the mercury barometer, the balance barometer does not seem to possess.

Fossiliferous Granite.—M. Reinsch, inspector of mines at Gotha, states that he has recognized microscopic organic remains, both animal and vegetable, in certain granite rocks which have hereto-

fore been reputed to be of igneous or eruptive nature; and Dr. Müller mentions a phenomena which has some analogy with the preceding, viz: the existence of living creatures in the waters of the geysers of California at a temperature of 202° Fahrenheit.

Quiet Ebullition of Liquids.—It is of great importance in many analytical and technical processes that the liquids with which one is operating should boil quietly and with regularity, without that fitfulness and bumping with which all are familiar. It is in this connection that attention is directed to a communication of Th. Schumann,* according to which this object may be accomplished in most cases by the following method:

A glass tube about ⅛-inch in diameter is taken; this is melted shut at one end, and bent into the form of a hook, while the other end is left open. The tube, which should be about an inch shorter than the distance from the stopper to the bottom of the retort, is then hung by a string from the tubulure. As the liquid is heated, the air in the tube expanding gives rise to bubbles, which regularly ascend; and when the boiling point is reached, vapor of the tension of the atmosphere is formed at the open end of the tube, and the process of ebullition is carried on for days with regularity and quietness. When an operation is interrupted, or the retort filled with fresh material, it is necessary to remove the tube from the liquid, and then to introduce it afresh.

C. Winkelhofer† recommends for the same object that an artificial generation of gas should be kept up in the liquid during the operation, which he accomplishes by passing a galvanic current through it. The action of one of Bunsen's Elements, of ordinary size, is said to be sufficient for the purpose, the wires being of copper or of platinum, as the nature of the boiling liquid may require. It is plain, however, that this plan can have but a limited application in practice.

Pharaoh's Serpents.—These, once so largely popular toys, have been almost entirely abandoned, owing to the poisonous character of their constituents and of their fumes. Dr. Puscher now announces that a mixture of 2 parts of bichromate of potassa, 1 part of nitrate of potassa and 3 parts of white sugar will produce the effect of the serpents without the attendant inconveniences. He

* Am. Jour. Pharm., XLI, 527.

† Dingler's Polytech. Jour., CXCIII, 80.

recommends the mixture to be done up in paper or tin-foil cones, and also the addition of some Balsam of Peru to perfume it.

A New Experiment.—The action of Dilute Sulphuric Acid on starch is very neatly illustrated in a new experiment suggested by A. Vogel. It is well known that writing paper is so largely sized with starch that an iodine solution applied upon its surface will produce a blue color. Vogel traces first upon the paper some writing or figures with dilute sulphuric acid. The paper is then gently heated, but not sufficiently to char it. If now the iodine solution is applied, portions of the paper treated with the acid remain white, while the rest is blued. The same paper will serve repeatedly for the experiment, for the blue color gradually disappears.

Reagents for Ozone.—Lamy* has published some results of experiments upon the reliability of Ozonoscopic papers, which he has tested upon an extended scale and in a variety of situations. He announces that paper moistened with the oxide of thallium, when freshly prepared, is far more sensitive towards Ozone than that prepared with iodide of potassium and starch. The sensitiveness of this reagent (thallium oxide) depends upon the strength of the solution, and upon the extent to which the oxide has absorbed carbonic acid. Where a rapid and reliable test for the presence of Ozone in an atmosphere is desired, the thallium paper is recommended as preferable to the other, though it is not adapted for determining the quantity of this substance.

A Spontaneous Explosive.—Some experiments recently conducted at the Philadelphia High School developed the fact that when a strong solution of phosphorous in bisulphide of carbon is poured upon finely powdered chlorate of potassa resting on paper, and the mixture exposed to air, upon the evaporation of the bisulphide of carbon, the phosphorous being left in a very finely divided state, intimately mixed with the chlorate of potassa, the mixture presently explodes spontaneously, with a loud detonation. The explosion in this instance is analogous to the case of phosphorous and chlorate of potassa when struck or rubbed together, the mixture of the two substances in the present case being, however, much more perfect than can be obtained by any mechanical means. E. T.

Estimation of Chloral Hydrate.†—It is well known that the value of chloral hydrate is determined by the action of caustic

* Bullet. de la Soc. Chim. de Paris.

† Zeit. für Chemie., 1871, p. 66.

alkali upon it, and C. Muller proposes the following method of making the estimation: A glass tube graduated from the closed end upward into $\frac{1}{10}$ cc, is filled with 25 grs. chloral hydrate, and then a slight excess of caustic alkali is added, and the tube is closed with a cork. At the end of some hours, the liquid in the tube is divided into two portions of different gravities, the line of separation being clearly and sharply defined. It is only necessary to read off the number cc. of chloroform, which has been formed by the action of the alkali upon the chloral hydrate, then multiply by its specific gravity (allowance being made for the temperature), in order, by a simple calculation, to find what per cent. of chloroform has been formed. A. R. L.

Action of Water upon Iron and of Hydrogen upon Ferric Oxide.—There is a very striking and important article upon this subject, by H. St. Claire Deville, in the *Comptes Rendus*, LXX, 1105. The iron to be operated upon was placed in a boat of platinum, and this again in a porcelain tube. To maintain the iron at constant temperatures various devices were resorted to. For those below 300° C. an oil or mercury bath was used, which was heated by a gas flame regulated by Schloesing's apparatus. The constant temperature of 860° was obtained from cadmium vapor, and of 1040° through zinc vapor. The zinc is placed in a black-lead crucible such as is employed in the manufacture of steel, and containing about 20 kilogrammes of the metal. Two holes are bored through the sides of the crucible, through which an earthen tube is passed, and through this again one of porcelain. The distilled zinc is condensed by a suitable apparatus. For temperatures above 1040° the porcelain tube is heated directly in the flame of an oil lamp. The brass stop-cocks by which the porcelain tube is terminated are made double, so that a stream of water circulates through them, and prevents the destruction of the connections. One cock is connected with a retort containing water, the other communicates with a reservoir of hydrogen and with a Geissler or Sprengel pump.

In this way, Deville treated pure iron with steam at known tension and temperatures. The temperature during each experiment was maintained constant, but was varied during the course of all the experiments from 150° to 1600°. He thus obtained the following remarkable result—that if any weight of iron be subjected at a certain temperature to the action of steam, the iron is oxidized until the tension of the liberated gas rises to a certain point which

is unalterable for that temperature. This tension amounts to a very small fraction of the barometric pressure.

Since the tension does not depend at all upon the quantity of iron, the hypothesis of Berthollet, known as the Influence of Mass upon Chemical Affinity, does not by any means appear to explain the phenomena. Indeed, these experiments go to show that this hypothesis should be rejected as untrue.

When the highest pressure of steam in the apparatus, which corresponds to a certain temperature and pressure, is attained, and a certain amount of hydrogen is removed, the tension, which has undergone a momentary alteration, returns to its normal point, by the decomposition of a fresh quantity of water evaporated from the retort connected with the apparatus. If hydrogen is added, so as for a moment to increase the tension, it diminishes gradually again, while a certain quantity of ferric oxide is reduced, and water forms, which is condensed in the retort.

It follows that the hydrogen which is liberated in contact with iron, acts in accordance with the same law of hygrometry as is true in the case of steam, *i. e.* in a variable space maintained at a constant temperature, steam evaporates or condenses until the space is saturated with vapor. A. R. L.

Color Changes produced by Heat.—In our March issue, attention was called to the remarkable property of changing color possessed by certain newly discovered iodides of mercury, copper and silver, upon the application of moderate heat. Since the publication of the notice, Prof. Edwin J. Houston* has succeeded in detecting the law which underlies this curious phenomenon, and has also discovered that nearly all metallic compounds, to a greater or less degree, possess the same property; a discovery as important as it is interesting.

The Psychic Force.—In an article entitled "Experimental Investigation of a new Force," Dr. William Crookes,† F. R. S., details a number of experiments conducted by himself in company with other widely known scientific men, with a view of testing the reality of certain phenomena which have, for reasons too well known to need repetition in this place, received but little attention from men of science. The phenomena in question are, from some ridiculous theory

* On the Change in Color produced in certain Chemical Compounds by Heat. *This Journal*, LXII, 115.

† From advanced sheets of the *Quarterly Jour. Sci.*, July, 1871.

as to their origin, termed "spiritual"—a name scarcely calculated to inspire an investigator with confidence in the genuineness of the manifestations, nor to invite examination. The only published attempt to apply to them the analytical methods which are found of such service in investigating natural phenomena, is that of Tyndall (Fragments of Science, Chap. Science and Spirits), and the record of his experience is not of a character to strengthen the desire to investigate this subject. The investigations of Crookes, however, the main features of which are now about to be presented, led their author to a different conclusion; the results of his experimental tests being the announcement of the existence of a new force, in some unknown manner connected with the human organization. To this force he applies the name of the Psychic Force. The experiments were conducted upon Daniel Dunglas Home, one of those persons known as "mediums," upon the theory formerly alluded to.

Among the curious phenomena which occurred under his influence, we are informed, were the increase in weight of bodies, and the playing upon musical instruments, without direct human intervention, under conditions rendering contact or connection with the keys impossible. The conditions under which these curious results were obtained are fully and clearly stated.

The detail of the experiments are too extended to be more than briefly noticed, and this notice will be confined to that of the increase in weight, which is the most unexpected. The apparatus consisted of a mahogany board, 36 inches long by 9½ inches wide, and 1 inch thick. One end of this rested on a firm table, while the other end was supported by a spring balance, hanging from a substantial tripod stand. An automatic register was attached to the balance, which recorded the maximum weight indicated by the pointer. The board was horizontal, and the index before the experiment indicated a pressure of 3 pounds. The fingers of the actor, we are informed, were placed lightly on the extreme end of the board, which rested on the support, and the points of the balance immediately descended; it shortly rose again. This movement was repeated several times, as if caused by a succession of waves.

The extreme depression of the index indicated 9 pounds, a maximum pull of 6 pounds. The weight of one of the party, 140 pounds, applied to the place where the fingers of the actor had been, sunk the index but 1½ pounds.

These are the facts of the case as stated by the author, and the

article will be read with interest by all who desire to see brought to the light whatever of truth there may be enveloped in a monstrous tissue of fraud and deception, whether we are disposed to admit or to deny the explanation he offers of a new force—the Psychic force—to account for his results.

Behavior of Lithium Minerals in the Spectroscope.*—In the course of an investigation by von Kobell, of various minerals containing lithium, he made the curious observation that when such minerals color the flame red, it by no means follows that they exhibit the red lithium line in the spectroscope. This is not always the case, but appears to depend upon the construction of the instrument, whilst one shows the lithium line the other does not. Von Kobell's instrument, for example, in the case of an Asbolan and Psilomelane, showed the line only when the piece under examination was moistened with hydrochloric acid. The Cookeite, from Hebron, the Lithionite, from Paris, Me., showed the lithium line without aid, although the flame was merely colored yellow. The lithionites, from Zinnwald and Altenberg, on the contrary, do not show the line directly, and yet color the flame red. But all the lithionites do show the line when some fragments are melted, the glass rubbed to powder and moistened with hydrochloric acid before being brought into the flame. A. R. L.

Horse-Power of Steam Boilers.—Under its appropriate heading there is published the report of the Institute Committee, appointed to examine this question, and to fix, if possible, some uniform plan or principle which will prove acceptable to all parties in rating steam-boilers. As will be perceived upon inspection the report is but preliminary to a more complete and final one, which the committee hopes to be able to present to the Institute at no distant day.

The conflicting nature of the testimony of boiler-makers and others on some practical points, has made it necessary for the committee to extend its inquiries over as wide a field as possible, and to invite all who are interested in the acceptable solution of this interesting practical question to furnish it with the results of their experience to aid in securing a report which shall possess the largest claims for support.

* Jour. für Prakt. Chem. 1871, p. 176.

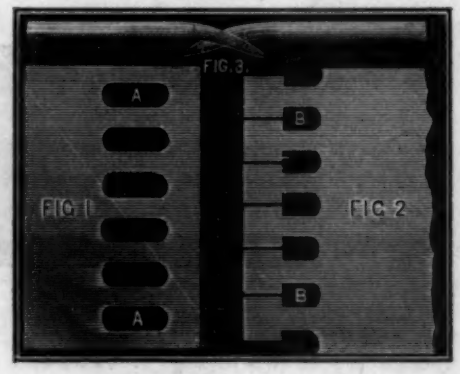
Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 39.)

Connecting the ends of belts.—"Two or more oval slots, A A, Fig. 1, are made near one end of the belt to be joined, and in the other end, Fig. 2, of the same belt, D-shaped slots, B B, are made, the material being cut through from the middle of the straight side of the D, by an incision parallel to the length of the belt, thus dividing the end into T-shaped parts.



"The ends of the belt are scarfed, so that when engaged, they will lie closely to the body of the belt.

"In connecting the ends of the belt, the T-shaped parts are twisted quarter-way round and passed through the oval slots in the other end, and then straightened up again, thus locking the ends without the aid of laces, metal clips or buckles."—*Howarth. Mech. Mag. London*, XCIV., 289.

From C. F. Scholl's Mechanic's Guide, page 483, 4 *&* 5, *we take the following:*

"Pulleys must be true and concentric, and their shafts parallel, otherwise belts which run upon them must be guided, and the guiding device will wear their edges rapidly. To prevent belts from running off, pulleys should be made convex on their faces, much convexity, however, is destructive to thick and to double belts.—Pulleys for shifting belts should be parallel-faced, except where the shafts are far apart, when they may be convex. Flanges to pulleys and belt guides should be avoided, except to pulleys on upright shafts which have a slower motion, and where two belts run closely on the same pulley, or on two pulleys of like size; but for high speed they may be discarded.

"The softer woods are better for pulleys than the harder kinds,

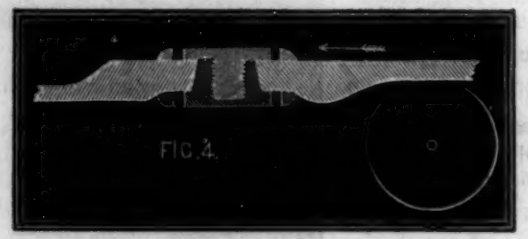
but pear wood and nut-tree are best for cord wheels. Grease must not be put on wooden wheels on which belts run.

"Tighteners must be applied to the slack side of belts.

"Good oak-tanned wild leather is the best for belts, and not that prepared with alum.

"The belts should be cut from the centre of the skin, stretched, and of even thickness throughout. The ends are joined by leather laces, rove through uniformly punched holes.

"New belts are liable to stretch, and should be unlaced, shortened, new holes punched and then laced again.



"The most practical method of fastening the ends of belts, is by the screws shown in Fig. 4. The belt must travel in the direction of the arrow, and never allowed to run against the joint.

"The method shown in Fig. 5 is also recommended. The plate is of brass, rather narrower than the belt, curved to the pulley, laping the joint, and receives countersunk head screws from each end of the belt.

"In Fig. 6 another plan is shown in which incurved teeth of malleable iron connected to a plate, are driven through each end of the belt when butted, and are then clinched on the inside.

"Thickness of belt does not always give strength. Small pulleys injure the structure of the belt by too great flexure. Single belts are relatively more durable than compound belts, the latter should be used only on large diameter of pulleys. Gum belts and belts of

which gum forms a part, are preferable in damp localities, but they should not be shifted much.

Horizontal running belts should be long; their own weight doing the required work without excessive tension, but is limited to a shaft distance of about 28 feet. At a greater distance than this, especially at high speeds, belts sway injuriously from side to side.

"Powdered Colophonium may be applied to a slipping belt.

"Belts driving mills at high speed, work better than toothed wheels, and all machines subject to intermittent motions, or liable to sudden stoppage, should be driven by belts.

"Fat should be applied to belts, say every three months of their use: they should first be washed with luke-warm water, and then have leather grease well rubbed in.

"A good composition which should be applied warm, consists of:—

Lard or Tallow	1 part.
Fish Oil	4 "
Colophonium	1 "
Wood Tar	1 "

(To be continued.)

PRELIMINARY REPORT OF THE COMMITTEE APPOINTED TO EXAMINE INTO THE MODES OF DETERMINING THE HORSE-POWER OF STEAM-BOILERS.

At the stated meeting of the Institute, held June 21st, the following partial report of its labors was presented by the chairman of the committee:—

The committee to which was referred the consideration of some definite rule for determining the horse-power of steam-boilers, beg leave to report as follows:—

In a thorough examination of this question, it is necessary first to advert to the origin of the term horse-power, and the manner in which it was first used to designate the power of the steam-engine.

The early demand for the steam-engine was to effect some task before performed by horses, and it became a question of comparison of the new mechanical with the animal motor.

From experiments made to determine the actual power exerted by good average horses, it has been found that a horse working for 8 hours per day, will exert a force equal to about 23,400 lbs., and

when working for 3 hours only, will exert as much as 32,900 lbs. raised one foot high per minute.—(See Ure's Dictionary.)

The example taken as a unit by James Watt, was that given by the heavy dray horses of the brewers of London, whose maximum performance in hauling was found to be 150 lbs. at 2½ miles per hour; equal to 33,000 pounds lifted one foot high in a minute.

This has since remained the standard for a horse-power both in the English, Continental and American practice.

This unit of power exerted upon the piston of the steam-engine, measured by the instrument known as an indicator, is termed the indicated horse-power; and the power given out by the engine to the machinery is the actual or effective horse-power, being the indicated power minus the friction of the engine.

There is, also, the nominal power, a term based upon the size of the cylinder and arbitrarily assumed speed of piston and pressure of steam. This might also be termed the commercial power of the engine.

Watt, in the construction of steam-engines after the type established by him, adopted for the speed of the piston 128 times the cube root of the stroke in feet; and assumed 7 lbs. as the effective pressure upon the piston.

He thus obtained a nominal horse-power which, under the most unfavorable circumstances, his engines were sure to produce.

Then, again, we have the rule of the British Admiralty for marine engines, in which the old assumed pressure of 7 lbs. is adhered to, but the *actual* speed of the piston is taken into account.

Another rule for the nominal power of high pressure engines has the authority of Bourne, who assumes the speed of the piston to be that given by Watt, and the effective pressure on the piston to be three times as great, *i. e.*, 21 lbs. per square inch.

His rule is, multiply the square of the diameter of the cylinder in inches, by the cube root of the stroke in feet, and divide the product by 15⅞. Thus we find a great diversity in the rules for estimating the nominal power of engines. This nominal power, the power at which the engine is rated by the maker, has gradually become greater as the speed and pressure have been increased.

But in *all cases* the nominal power is *much less* than the actual power at which such engine is capable of working with the average pressure and speed common to engines of that class.

Going back to the historical era of the use of steam, the com-

mittee find that at an early day, although subsequent to Watt's time, the evaporation of a cubic foot of water per hour, from and at the temperature of 212°, was ruled to be the measure of a nominal horse-power.

All subsequent authorities, without exception, have adopted this standard;—in the *steam boiler* they make no distinction between the nominal and actual horse-power; there is only one definition of the term, and that is the evaporation of a cubic foot of water as previously stated. It is with this definition that we use the term horse-power.

This rule appears yet to be applicable, and it only needs some statements of conditions, such as will allow purchasers and sellers to conform to this requirement.

For stationary boilers with natural draft, assuming that the chimneys and flues shall be adequate in size and form, to afford the necessary draft, and that the fuel is coal of average good quality, it appears that nearly all writers give about $\frac{55}{100}$ square foot of grate to each horse-power of boilers, and as this ratio gives a very small grate for the lesser number of horse-power, about 2 feet are added as a constant.

Having thus designated the means for burning the fuel, the conditions attached to the horse-power of boilers are within some limit as to quantity of fuel to be used in producing this effect.

In other words, the arrangement and extent of heating surface should be such that at least the average result by evaporation of 9 lbs. of water from and at 212° with one pound of good anthracite coal burned (over and above ashes) shall be attained.

As there are 59·48 pound of water at 212° in a cubic foot, it follows that 6·61 pounds of coal will be needed for its evaporation.

Adopting the more convenient number of 7 lbs. as a liberal allowance, the rule would be $\frac{7 \text{ H. P.}}{0{\cdot}55 \text{ H. P.} + 2} =$ the number of pounds burned per hour per square foot of grate; or for boilers of—

10 H. P.	7½ square ft. of grate	9·33 lbs. per hour per sq. ft. of grate.	
20 "	13 " " "	10·76 " " " "	
40 "	24 " " "	11·66 " " " "	
60 "	35 " " "	12·00 " " " "	

It may be as well to refer to chimneys and flues, and add that the average heights of chimneys above the surface of the grate, for

stationary boilers, should be taken as from 50 to 60 feet, and the sectional area to conform to Boulton and Watt's rule (as quoted by Bourne,) which is,—"Multiply the number of pounds of coal consumed under the boiler per hour by 12, and divide the product by the square root of the height of the chimney in feet, and the quotient is the proper area of the chimney in inches at the smallest part."

"The rule, though appropriate for land boilers of moderate size, is not applicable to powerful boilers with internal flues, such as those used in steam vessels in which the sectional area of the chimney is from 6 to 8 square inches per horse-power."

The sectional area of tubes or flues, and the setting of the boiler must also be properly proportioned, so that the escaping gases, as they leave the steam generating surface, be not more than 300° above the temperature of the steam.

The above conditions apply particularly to stationary boilers, with natural draft.

We have no intention, however, to limit the test of a boiler to these conditions of grate surface and chimney, they are incidentally mentioned as good average practice.

When a forced draft is employed, as in the locomotive, we find the heating surface 65 times the grate area, and 80 lbs. of coal burnt per square foot of grate.

These general conditions, dependent upon each other being fulfilled, viz., a grate surface so proportioned to the draft as to admit easily the combustion of 7 lbs. of anthracite coal, or combustible equal to that amount per horse-power per hour, and the escaping gases not over the temperature before mentioned; it may be safely asserted that a boiler so set, of any given horse-power, failing to evaporate that number of cubic feet of water per hour, with that amount of coal, does not produce its nominal horse-power.

We may also state, in connection herewith, that a cubic foot of water evaporated into steam, is abundance for one actual horse-power when used in the cylinder of an engine without expansion: when used in a three port slide-valve engine, cutting off during the last quarter, it will yield about $1\frac{1}{3}$ indicated horse-power; and will give as high as $2\frac{1}{2}$ indicated horse-power, according to the pressure of the steam, the point of cut-off and the type and efficiency of the engine.

In usual practice, the feed-water will be admitted to the boiler at temperatures varying from 40° to 200°.

To make the proper correction for 212°, and to ascertain the quantity of water which would have been evaporated had the feed-water been at 212°, we give the following rule:

The latent heat of steam being 966° and T the temperature of feed-water.

As 966 : (1178°—T) :: water evaporated : water evaporated at 212°.

It may be more satisfactory sometimes to ascertain the evaporative duty of a boiler, in connection with the horse-power developed from that amount of steam passed through the engine; in which case the formula immediately preceding will be varied, so as to substitute the temperature of the steam (latent and sensible) at the pressure used, for the figures 1178°.

The total temperature of steam for the pressure used may be taken from the table in Bournes' hand-book, page 159.

In order to reduce the evaporative effect of a boiler with different temperatures of feed-water, and of steam produced, to its equivalent evaporation of water from 212° to steam at 212°, the following formula is useful:

Let E = number of feet or pounds evaporated at 212° in a given time.

E 212° = number of feet or pounds evaporated under conditions taken.

T_w = temperature of water fed into the boiler.

T_s = temperature of steam formed in boiler.

$$E\ 212° = E\left(\frac{1114 + 0{\cdot}305\ T_s - T_w}{966}\right).$$

The amount of water carried over mechanically with the steam, is a feature which must not be overlooked, and the amount determined by one of the available methods.

The conditions of cleanliness of the external and internal surfaces of the boiler, and the maintenance of such cleanliness, cannot well be defined, but it is obvious that such conditions are essential in practice, and that no boiler without provision made for these purposes, and also for an efficient circulation can be a complete success.

There are several well-known types of boilers such as the plain cylinder, the horizontal flue and horizontal and upright tubular; the horse-power of which estimated by the heating surface could easily be established from a series of actual experiments, and a certain

minimum amount of heating surface laid down as a rule for practice.

It is quite obvious that one of these, the plain cylinder for example, might be so badly set, or unskillfully fired, that the evaporative duty would be much reduced below the actual standard to which the boiler is entitled,

This deficiency could not be said to result from error of form or construction of the boiler.

Exceptional cases will sometimes occur in no way modifying the general rule herein laid down, viz: that the rating shall be ascertained under what is acknowledged by engineers as good conditions of practice. Were it otherwise, we should see a small boiler giving out its nominal power merely by an intense fire and red-hot chimney.

Much uncertainty in the purchase and sale of boilers would be obviated, if the horse-power were specified in connection with the pounds of combustible to be used per horse-power, (*i. e.*, per cubic foot of water evaporated) per hour.

So, also, the term horse-power when used in reference to steam-engines, would be better qualified by the words nominal, indicated or actual.

With all this variety of requirement it is safe to conclude that the old practice and definition of a nominal horse-power, gives ample protection to the sellers and buyers of boilers, when the conditions long ago established and herein stated are admitted.

Your Committee refer to the following as original authorities: Smeaton's Reports; James Watt Annotations to Dr. Robinson in the Encyclopædia; Farey on the Steam-Engine; Tredgold Steam-Engine; Bournes' (Artizans' Club) on the Steam-Engine; Bournes' Catechism and Hand-Book; Rankine's Steam-Engine and Prime Movers; D. K. Clark Railway Machinery; Fairbairn on Mills and Mill Work; Box on Heat; Peclet Traité de la Chaleur, and other works on Heat and the Steam-Engine.

Readers, however, who desire to investigate this subject will find in Rankine's Prime Movers, Bournes' several works, especially his Hand-Book, Fairbairn on Mills and Mill Work and Box on Heat, a complete exhibition of the theory and practice of steam-boilers.

The Committee have delayed handing in this Report with the expectation of being able to fix upon some definite amount of heat-

ing surface required per horse-power for well-known types of boilers.

We find, however, that boiler makers are far from unanimous as to the amount required, neither is their estimate always made upon the basis herein laid down; nor can we find any published account of any extended experiments sufficiently accurate to warrant the insertion of them in this report.

As it is likely several months may elapse before the Committee will be in possession of sufficient facts to satisfy them on this point, they are compelled to defer this portion of their report until a future occasion.

In the meantime they make the request to any engineers who have made or may make investigations bearing on this point, (viz., the heating surface required,) to forward the full particulars to the Secretary of the Franklin Institute.

EDWARD BROWN,
ROBERT BRIGGS,
JOHN H. COOPER,
W. BARNET LE VAN,
WILLIAM H. WAHL.

Hall of Franklin Institute, June 21, 1871.

Upon the reading of the foregoing, it was resolved that the Report of the Committee be received and printed in the *Journal*, in order to bring it more directly to the notice of the members, and that the Committee be continued.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By PROF. J. E. NOURSE.

ALTHOUGH the reports from the explorers on our Isthmus, who are now renewing the search for a practicable canal route, may not prove as favorable as could be desired, the great problem will lose nothing of its intrinsic interest. "The Canal must come," as Chevalier has said, in its turn. It is to be regretted that one of the two Government Expeditions now on the Isthmus has found itself in the field, each year, so late in the season in which proper work could be done. It is creditably reported of the other, the

Tehuantepec party, that it feels assured of having succeeded in its object.

As no full, yet succinct English memoir is to be found of the schemes, explorations professed or real, surveys or plans for opening up this long coveted passage, it is proposed to compile, for the Franklin Institute *Journal*, a historic memorandum, as a guide to those explorations. The writer will be able to claim at least an entire freedom from any bias toward a particular route—from all such temptations as are plainly seen to have had their force in coloring such a route when reported upon by the servants of a patriotic company. He will aim to present facts only; and to this end will gladly receive information from any of the numerous friends of the enterprise—promptly accrediting the same. There may be, on the part of companies, adventurers, and all others, a common and true desire to have the great work secured, and secured in our own day by Americans. May not the desire become a just expectancy?

The completion of the new route to the East, the Suez Canal, urges upon Americans, energetic and thorough explorations to secure a water communication across our own continent, lest Europeans entirely distance us, not only in energy and perseverance, but, in this lamentable day of the decadence of our shipping, in commercial rank. The Suez route is opening up the Indies to England and the Mediterranean cities, by voyages of but half the old required time or risk, and by commercial returns of untold wealth.

The great need in the matter of communication across our continent is, undoubtedly, a Ship Canal, if possible, without locks or tunnels, as Humboldt urges; at all events, a ship canal which will float the largest vessels of the merchant or the government marine. Through this the world's fleets should pass, without the disadvantage of being required to break bulk or employ lighters. Is the coast line and the physical geography of the interior at all favorable for such a transit? In this inquiry let us look for a moment at the marked characteristics of the GREAT AMERICAN ISTHMUS.

Central America, considered in the fullest extent to which the name is geographically applicable, well merits the title given above. Its general direction, the trending of its coast line, is from W. N. W. to E. S. E. The length of the longest line from the mouth of the Coatzacoalcos, Mexico, (N. Lat. about 18° 20′) to the mouth of the Atrato, New Grenada, (N. Lat. about 8° 15′) is estimated at about

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four hundred and fifty miles. Through this extent it has been called the "gigantic causeway which separates two oceans and unites two continents." Other noted Isthmuses in the world, separating only Gulfs which penetrate the interior, or perhaps a bay from a sea, are but a fiftieth or a hundredth part of the length just named. Our Isthmus divides the two great oceans of the globe.

Throughout its extent from Mexico to the Atrato, there are several short necks of land which seem to indicate, at first sight, the lines through which water communication may be made from ocean to ocean; especially toward the southern part of the Isthmus the land narrows to be far out of proportion to its length. This extreme relative narrowness, and the direction of the river courses down the two opposite slopes toward the two oceans, have kept alive, for the last three hundred and fifty years, increasing desires for an easy and rapid crossing; desires first, in part, satisfied by the completion, in 1855, of that herculean task, the Panama Railroad.

"The facts that where the oceans approach each other on this Isthmus she has supplied harbors of unsurpassed excellence on both sides, and navigable rivers that invite the traveller to penetrate the interior, and that she has also established on the one side a tidal connection in the highest degree favorable," are enough to make loud claims upon the nations to follow her hand-pointing until they have travelled successfully through the whole short, though arduous journey that leads across.

It seems to any one who has the map under his eye, that such a water passage ought also to be of the nature of a free Strait. "In width, depth, in supply of water, in good anchorage and secure harbors at both ends, and in absolute freedom from obstruction by lifting locks, or otherwise, it ought," says Admiral Davis, "to possess this character." Such a water communication, if it naturally existed, would be claimed by the trading nations of the world as one of their great highways. Would it not be clearly the right of all nations to pass through it, as their shortest route of communication with each other? Could any plea of supposed insecurity, or "immemorial usage" on the part of a nation bordering on such a passage be admitted in bar? Would not the spirit of the age, which has put an end to one such plea on the part of Denmark, readily find here also some equitable plan of capitalizing once and forever all these claims? It would be distinctly enough intimated, by

every dictate of reason and justice, that trade must pass freely. This would be as true here as for the Straits of Gibraltar.

"If," says Wheaton, "those Straits were bordered on both sides by the possessions of the same nation, and were so narrow that they were commanded by cannon shot from both shores, this passage would not be less freely open to all nations, since the navigation of the Atlantic and the Mediterranean is free to all, and *all have the clear natural right to reach the countries beyond.*

Historic interest of the Problem.—"The problem of interoceanic communication," said Charles Sumner in the United States Senate in 1867, "has not only a practical value but an historic grandeur. From the time of Charles V, one of the aspirations of Spain and of all adventurers and navigators in those seas, for many years, has been to find what was called a gate by which to pass through the Isthmus into the other ocean." The search for it is identical with the voyages of discovery on the western coasts *from Behring's Strait to Cape Horn.*

The points in its history now brought together are chiefly from the pen of our countryman Squier; from M. Chevalier, the French statesman and scholar; Admiral Fitzroy, R. N., the late British hydrographer; and Malte Brun, Jr., of the Geographical Society of Paris. Chevalier not only thoroughly studied the subject of canalizing the Isthmus, but visited it, and more than once made vigorous movements in the interests of this question, for other ultimate purposes than the canal—for the upholding of the cause of monarchy and of the Latin race on this continent. He holds a charter for a canal across Nicaragua, dated in 1869. In an elaborate discussion in the *Revue des deux Mondes*, 1844, entitled "L'Isthme de Panama, L'Isthme de Suez," he tells the following strange but true story of the apathy and neglect of all enterprise in this matter by

The Government of Old Spain.—The thought of opening a route from Europe westward to China and Japan is no new thing. Columbus had this one aim when setting out from Spain. He afterwards supposed that he had landed on a part of the dominions of the Emperor of China, "the Grand Khan." He died believing, after four voyages, that he had indeed reached Asia. He never saw the Pacific. That honor was reserved for one of the most remarkable men of Spain, then so fruitful in heroes—Vasco Nûnes de Balboa.

We cannot recall his name without the feeling of profound sympathy as well as admiration. The New World was born indeed in

the sufferings of those who gave it European civilization. Columbus, in chains, and Cortez, at the close of life, abandoned as some obscure adventurer, and dying of grief, are the two chief figures in the picture which sheds but little honor on humanity; by their side appears also the heroic Balboa, perishing upon the gallows. Eager to secure the sanction of the Spanish Court for the position of chief in the little colony of Santa Maria, Balboa made explorations among the neighboring tribes on the Isthmus, and thus acquired the information that "an ocean lay at a distance of six days' journey, and, adjoining it, an empire abounding in gold." The natives meant by this the country of Peru. Balboa undertook to penetrate the unbroken forests and reach the mysterious sea.

On the 25th of September, 1513, he at last gazed upon the ocean from the summit of the Sierra Quaragena, which he had not permitted anyone but himself to climb. Then, falling on his knees, he gave thanks to the Almighty for having reserved for him the glory of a discovery so profitable for his country. Some days after, arriving on the coast, clad in armor, with shield and drawn sword, he breasted the waves of the Great Sea, claimed it for his sovereign, and swore to defend it for him.

The court of Spain was thrown into raptures on receiving his dispatches. The key to the treasures of the vast Indies, till then in the hands of the Portuguese, seemed now delivered up. Instantly they resolved to pursue such advantages. But the affairs of the Indies were then unhappily directed by one of those miserable creatures to whom another's fame is an insupportable burden, and whose great happiness seems to consist in torturing all noble characters to whom they see the multitudes giving their admiration and regard. Such a man was Fonseca. He had cunningly plotted against Columbus, even while he was living under the protection and bounty of Isabella. He pursued the illustrious Admiral with unsparing hate, to the injury of his heirs; and he had consummated his infamous intrigues by plotting the assassination of Cortez, solely because of his great fame. Fonseca, instead of giving the command of the expedition to Balboa, chose an obscure man, Davila, one of whose first acts was to impose a heavy fine upon Balboa for some alleged old irregularities in other districts.

When Balboa was preparing to sail down the coast to Peru, which no one had as yet reached, Davila, though previously reconciled to him, and now allied to him by marriage, suddenly caused his arrest;

condemned him by the ageney of his minions, and executed him despite the entreaties of the colonists.

The existence of another ocean once established, it was still unknown whether America formed one continent or was broken into masses by any narrow arms of the sea. To determine this question there were many expeditions during the earliest part of the sixteenth century. Sebastian Cabot, in the service of England, had already visited Labrador in 1497–'98, in search of the northwest passage to India. In 1499 and 1500, the Florentine, Amerigo Vespucci, had coasted Central America from the Gulf of Darien to the shores of Venezuela and Guiana.

In 1500, one of the glorious companions of Columbus, Vincent Y. Pinzon, took possession of Cape St. Augustin, and discovered the mouth of the river of the Amazons; and one of the three Cortereals, Frenchmen remarkable for their bravery, and still more for their brotherly affection, made a voyage of discovery for the King of Portugal, as far as the mouth of the St. Lawrence. In this same year, Pedro Alvares de Cabral, by accident discovered the coast of Brazil, while on his route to the Indies by way of the Cape of Good Hope.

Popular rumor exaggerated these discoveries. Men began to think, as Voltaire afterwards said, to the honor of Columbus, that "creation was really doubled;" and, justly enough, that these new countries must be distinct and separate from India, China and Japan.

In the mean time, the great successes of the Portuguese troubled the sleep of Ferdinand and his counsellors. For the Portuguese, led by De Gama around the Cape of Good Hope, had quickly reached the populous India of Alexander the Great, a country renowned all over Europe for its pearls and spices. They had thus covered themselves with glory, and brought home a vast amount of treasure.

The Spanish discoverers, as yet, had not reached the countries either of Montezuma or of the Incas. Everything, then, of personal ambition and national pride, the thirst of gold, the zeal of religious proselytism, and the cold calculations of state policy, now concurred in the disposition to sacrifice what Spain already had, of most value on the American shores, in order to seize upon a greater good—the Indies, still supposed to be near at hand.

To reach them it was said it was only necessary to find what has ever since been called "the Secret of the Strait;" that is to say,

some arm of the sea between the new countries which would give a passage directly westward to the land of spices. In 1508, a great expedition for this purpose coasted Brazil. In 1515, Juan de Solis entered the La Plata. He was massacred by the natives, and his expedition, with others, served only to show that the east coast of America was an unbroken continent.

On their side, the Portuguese made like search. After the explorations of the Cortereals toward the north-west, Magellan, in 1517, offered his services to the court of Spain, affirming that he knew where there was a passage to the Pacific, on the south, "for," said he, "I have seen it traced on a chart by the famous Geographer of Nuremburg, Marten Behaim." This was poor authority, for how could Behaim know of such a Strait? Magellan was, however, entrusted with a squadron. He set sail, and, in fact, did enter, in October, 1520, the very Strait which bears his name, and passed through it to the Pacific.

This passage, however, served only to gain for the Spaniards Chili and Peru. It was too far off to bring any communication with India; it was dangerous; and when afterwards Cape Horn had been reached by Le Maire and Schouten, sent by the Dutch—rivals also for the land of the Strait—for a time it was abandoned by navigators.

At the very time that Magellan was entering his Straits, Cortez was conquering Mexico. During his short friendship with Montezuma, he asked him the secret of the Strait, and the possibility of finding on the Mexican shore of the Atlantic a better anchorage than Vera Cruz. According to a despatch from Cortez to Charles V, Montezuma sent, in reply, a chart, on which the Spanish pilots recognized the mouth of a great river, which Cortez sent immediately to explore. It was the Guasacoalcos. It was fully ascertained that no Strait existed there, but it seemed likely that easy communication could be made between Coatzacoalcos and Tehuantepec by means of this river and the Chimalapa. Hence, large workshops were built at Tehuantepec and Grijalvas, and expeditions were despatched thence toward California, to the same great end and purpose of discovering the Strait. The vessels in which Cortez embarked at Chametla for the same destination were built at the mouth of the Chimalapa, of materials brought by way of the Guasacoalcos.

Cortez himself, in reply to a communication from the great Charles in 1523, enjoining on him to seek most diligently for "el

Secreto del Estrecho," laments the failure of the search, but does not abandon hope that still he may discover the route which would, as was supposed, shorten by two-thirds the voyage from Cadiz to Cathay and the land of spices, and "make the King of Spain master of so many kingdoms that he might consider himself Lord of the world."

Very soon, however, the hope of finding the Strait near the Gulf of Mexico or along the Isthmus was utterly destroyed. Elsewhere the pursuit was continued by the English. Hudson and Baffin gave their names to places first visited in the search.

In the first part of the eighteenth century, the Swede, Behring, in the service of Russia, proved that the American and Asiatic continents were separated, but he miserably perished on the island that still bears his name, near the Strait that also keeps it.

NOTE.—A new interest in Behring's search for the route is awakened by the transfer to the United States of the lands to which, in 1785, he led the way for Russia.

"Russia, shut up in a distant interior, and struggling with barbarism, was scarcely known to the other Powers at the time they were lifting their flags in the western hemisphere. At a later day the same powerful genius which made her known as an empire set in motion the enterprise by which these possessions were opened to her dominion. Peter the Great, himself a ship builder and a reformer, who had worked in the ship yards of England and Holland, was curious to know if Asia and America were separated by the sea, or if they constituted one undivided body with different names, like Europe and Asia. To obtain this information he wrote with his own hand the instructions, and ordered his chief admiral to see them carried into execution.

"The Czar died in the winter of 1725; but the Empress Catharine, faithful to the desires of her husband, did not allow this work to be neglected. Vitus Behring, a Dane by birth, and a navigator of some experience, was made commander. The place of embarkation was on the other side of the Asiatic continent. Taking with him officers and ship builders, the navigator left St. Petersburg by land Feb. 5th, 1725, and commenced the preliminary journey across Siberia, northern Asia, and the sea of Okhotsk to the coast of Kamschatka, which they reached after infinite hardships and delays, sometimes with dogs for horses, and sometimes supporting life by eating leather bags, straps, and shoes. More than three years were passed in this toilsome and perilous journey to the place of embarkation. At last, on the 20th of July, 1728, the party was able to set sail in a small vessel, called the Gabriel, and described as 'like the packet boats used in the Baltic.' Steering in a northeasterly direction, Behring passed a large island, which he called St. Lawrence, from the saint on whose day it was seen. Continuing northward, and hugging the Asiatic coast, Behring turned back only when he thought he had reached the northeastern extremity of Asia, and was satisfied that the two continents were separated from each other. He did not penetrate farther north than 67° 30′. By another dreary land journey he made his way back to St. Petersburg in March, 1730, after an absence of five years.

"Behring first saw the continent of North America on 18th July, 1741, in lati-

tude 58° 28′. Looking at it from a distance, 'the country had terrible high mountains that were covered with snow.' Two days later he anchored in a sheltered bay near a point which he called, from the saint day on which he saw it, Cape St. Elias. He was in the shadow of Mount St. Elias. * * * * * * * * *

"The desire of the Russian Government to get behind the curtain increased. Behring volunteered to undertake the discoveries that remained to be made. He was created a commodore, and his old lieutenants were created captains. The Senate, the Admiralty, and the Academy of Sciences at St. Petersburg all united in the enterprise. But on his subsequent voyage he was driven, like Ulysses, on the uncertain waves. A single tempest raged for seventeen days, so that the ancient pilot, who had known the sea for fifty years, declared that he had seen nothing like it in his life. Scurvy came with its disheartening horrors. The commodore himself was a sufferer. Rigging broke. Cables snapped. Anchors were lost. At last the tempest-tossed vessel was cast upon a desert island, then without a name, where the commodore, sheltered in a ditch and half covered with sand as a protection against cold, died 8th December, 1741. His body, after his decease, was 'scraped out of the ground,' and buried on this island, which is called by his name, and constitutes an outpost of the Asiatic continent. Thus the Russian navigator, after the discovery of America, died in Asia. Russia, by the recent demarcation, does not fail to retain his last resting place among her possessions."—*Sumner's Speech on the Treaty transferring Alaska.*

(To be continued.)

ON THE SOLUTION, MAINLY BY THE AID OF GRAPHICAL CONSTRUCTION, OF A PROBLEM IN PRACTICAL HYDRAULICS.

By Clemens Herschell, C. E.

The problem to be solved was the determination of the interior cross-section, and the position, relative to the level of low water, of a sluice having self-acting tide gates at its outer end, and which was to effect the drainage of a certain area of salt marsh bordering on the tidal portion of a small river. The data were, a number of observations of tides, giving a complete spring-tide and a complete neap-tide curve for 24 hours, at the point where it was proposed to place the sluice; the area of the marsh and appurtenant water shed; the quantity of fresh water coming down the river where the marsh begins, in freshets and ordinarily; the area of the river bed; and finally, the level of the marsh relative to the levels of the different stages of the tide.

It is intended in this article to exemplify also, in a striking manner, the utility of graphical construction in the solution of problems of this kind; indeed, without the aid of such a diagram it would, perhaps, have been difficult to devise the given method of calculation.

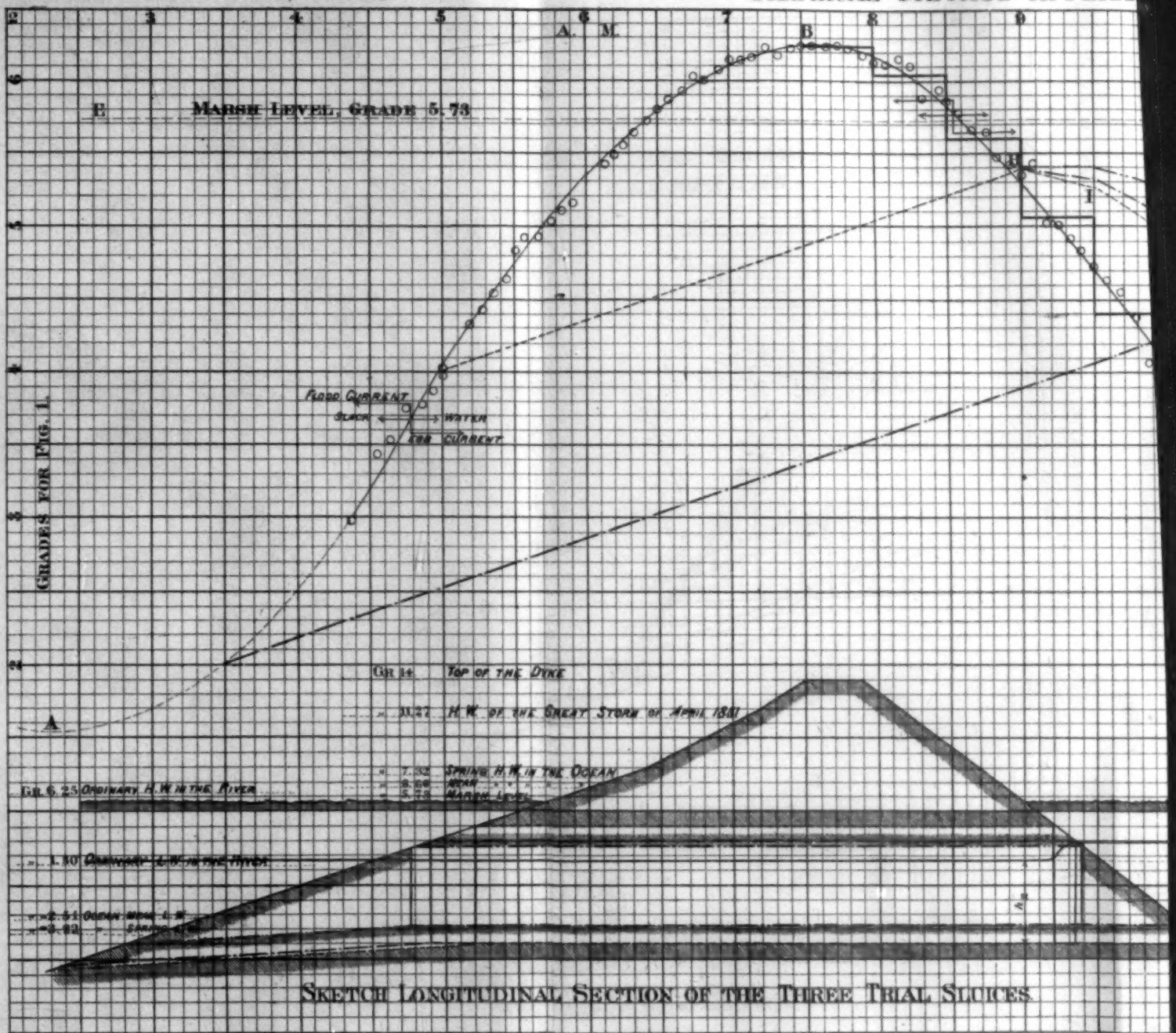
The calculations were made only for the most disadvantageous case; but, of course, there is nothing to hinder their being made for any of the possible circumstances. An inspection of the tide curves (by which is meant a plotting of the tidal observations, taking the times for abscissæ, and the observed heights for ordinates) showed that a neap tide would be most unfavorable for the drainage of the marshes, and a neap-tide curve was accordingly made the basis of the calculations. This curve is shown on the diagram, being the line A B C D, drawn as a full black line. The level of the marsh is shown by the line E F, on grade 5·73.* German authorities give as the depths below the surface to which the water must be drained, so as to enable the culture of various products, the following:

For different qualities of meadow hay, ...	1 foot to 1 foot 5 inches.
For corn and cereals.....	2 feet 4 inches.
For orchards and nurseries,.....	4 feet.

Let it now be supposed that the water stands in the river at a level of about 1 foot 9 inches below the marsh level, that is, on grade 4, at the time when the gates will be shut by the rising tide; in other words, the river is supposed to be nearly as full as it ever should be at the *close* of a period of drainage outflow. On the outside, the tide will then continue to rise as indicated by the curve A B C D; on the inside the water will also rise, it having no outlet —this rise depending (1) on the quantity of fresh water coming down the river at its outlet, this again being composed of the flow of the river where it enters the marsh, and on the direct drainage from the marsh and immediate surroundings; and (2) naturally, also, on the area of the basin in which the water rises, *i. e.*, the area of the river bed. The first is given us, for our most disadvantageous case, by the quantity of water flowing in the river, in freshets or ordinary high water, and was about 70 cubic feet per second.

An English rule for draining salt marsh is given thus: provide for the drainage of 0·0055 feet of rain per 24 hours over the whole area of the marsh; it seemed, however, to the writer, that in following this rule, which allows for so small a rain fall per diem, the marshes would undoubtedly be subject to overflow during heavy

* Many readers have, perhaps, felt the superior vitality, or power of interesting them, that the presence of numerical values gives to a mathematical problem; for this reason they have been introduced into this article (giving them as they entered into an actual example), instead of treating the subject generally, and using only algebraic values for the various data and results.



SKETCH LONGITUDINAL SECTION OF THE THREE TRIAL SLUICES.

GRAPHICAL METHOD APPLIED TO A PROBLEM IN HYD

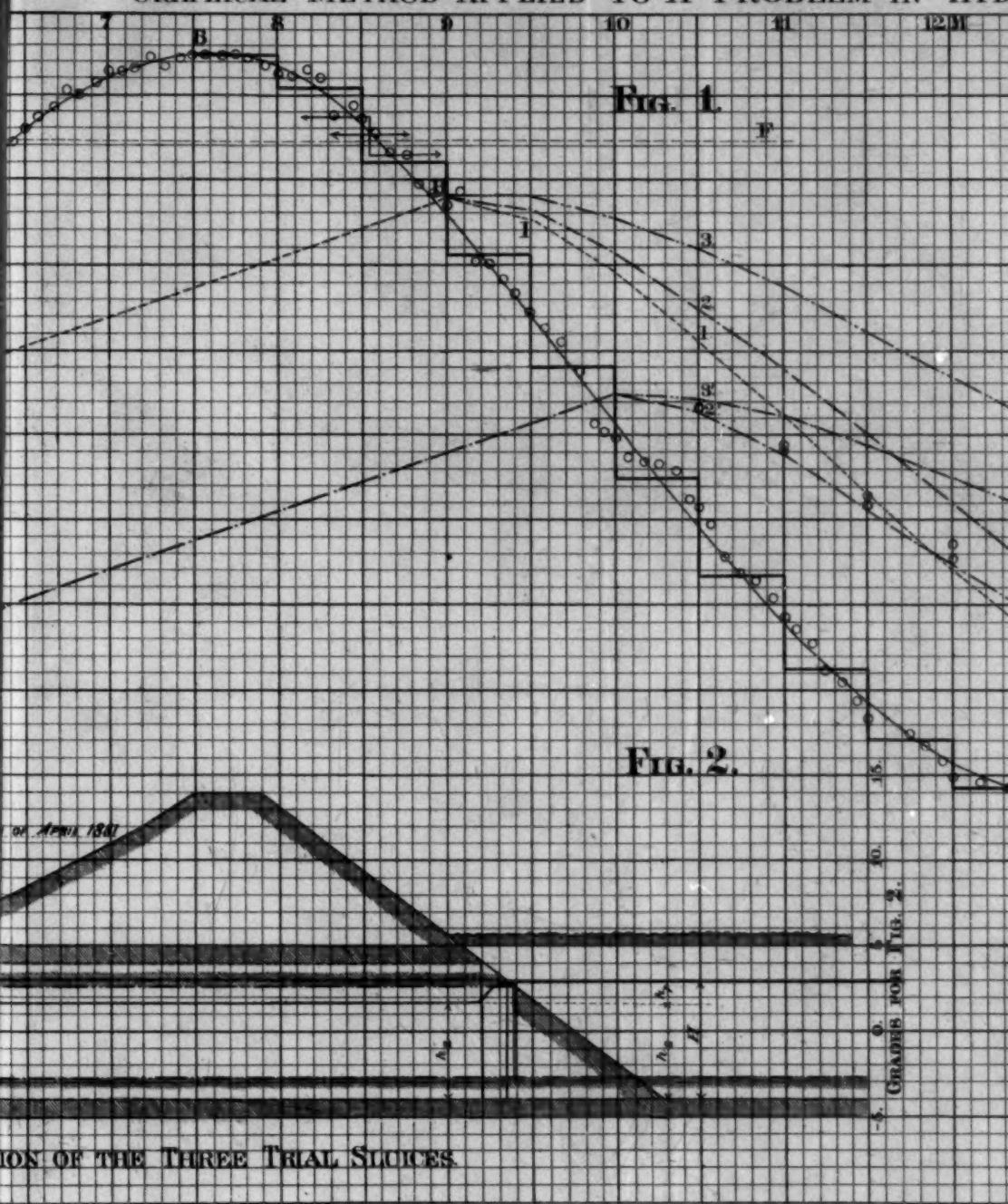
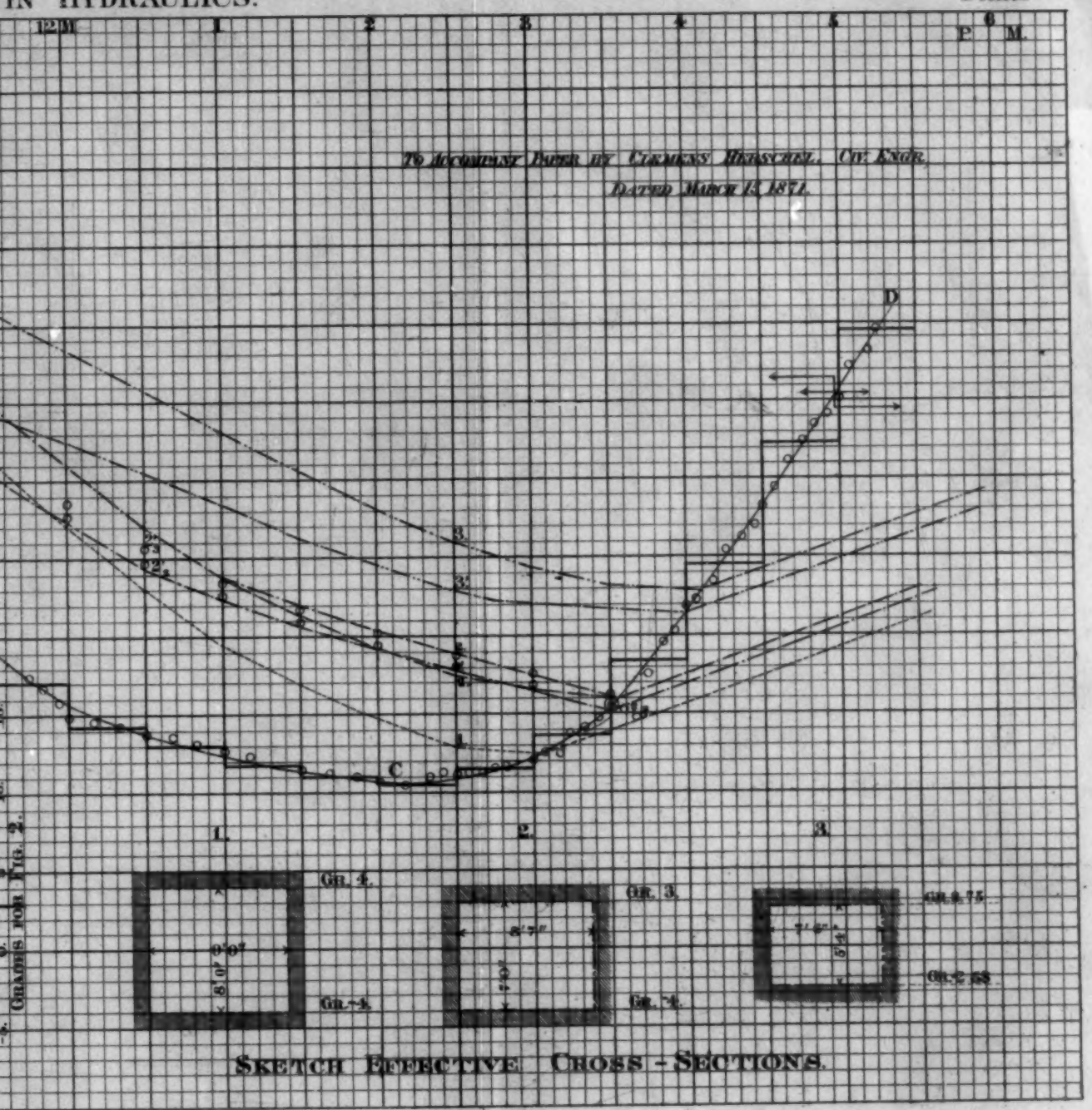


FIG. 1.

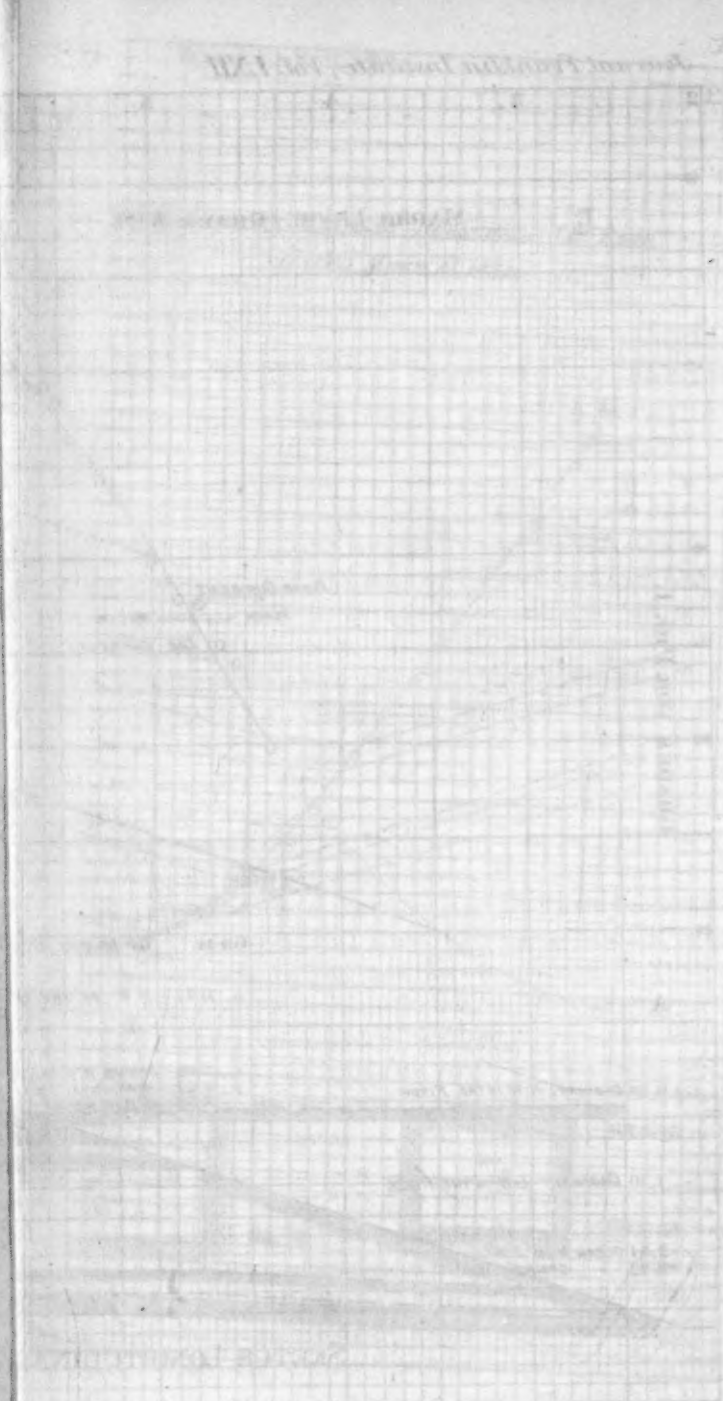
FIG. 2.

OF APRIL 1901

ION OF THE THREE TRIAL SLUICES.



SKETCH EFFECTIVE CROSS-SECTIONS.



rain storms. In preference to this, an effective rain fall of 2 in. = ·1667 feet per 24 hours over 1500 acres was therefore provided for. The area of the river bed was found to be about two million square feet, and this figure was adopted: also, for the sake of simplicity, it was supposed that the banks of the river were vertical.

With these data—a heavy rain storm and freshet together—it will be found that the water on the inside rises $\frac{0{\cdot}1667 \times 43560 \times 1500}{2 \text{ million} \times 48} + \frac{70 \times 1800}{2 \text{ million}} = 0{\cdot}176$ feet per half hour. This rise is represented by the straight line G H: had we taken into account the smaller area of the river bed at the lower grades, and the greater area at the higher ones, we should have had instead of a uniform rise one diminishing in height per unit of time as the water rises, that is, instead of a straight line G H, a curved one with the convex side uppermost. Where greater accuracy is required (and would be paid for), there is, of course, nothing to hinder the engineer from taking account of this, and other greater approximations, which will appear to have been neglected in the given calculations. The waters on the inside and outside coincide, as will be seen from the diagram, at 9 o'clock A. M. on grade 5·40, at which time the gates will open, or, at least, be in a state of unstable equilibrium. In order now to bring the calculation within the reach of ordinary mathematics, let us suppose that the tide rises or falls by steps, say every half hour. If we shall find that this will lead to any anomalies or defects of any serious kind, it will be easy to take a smaller space of time as the unit, until, finally, we shall get the desired regularity of results; in this case, half an hour proved to be as small an interval or differential of time as was necessary.

At 9 o'clock, then, the tide suddenly falls from grade 5·60 to grade 5·06, the water on the inside standing, as previously mentioned, on grade 5·40. We have, then, a head of 5·40 — 5·06 = 0·34 feet on the sluice for the next half hour, or, at least, we suppose that we have, in further assuming that the inside level is not appreciably altered by the outflow during the half hour. This last assumption again is slightly approximative, and could, under all the existing circumstances, best be made more nearly correct by taking a shorter interval of time as the basis of calculation.

The next step is to assume a certain cross-section of the sluice, and its position. To do this, in the first instance, there seems to be no guide, properly speaking, except engineering instinct. The only

rules for the cross-section of sluices used in the drainage of salt marshes, which the writer has been able to discover in engineering literature—to be found, for example, in Hagen's Wasserbau, Part III, Vol. I, 1862; or, Treuding Ent-and Bewässerung der Länderein, 1866; or in Buchholtz' Praktische Anweisung zum Bau hölzerner Abwässerungsschleusen, 1829—usually give the number of acres one square foot of sluice will drain, but generally do not pretend to fix definitely the position they pre-suppose for the sluice, or take into account any fresh water coming down a river, which water also must empty through the tide gates; sometimes, too, they give breadth without saying anything of height. In short, they are of little or no value to any one, unless it be to the inhabitants of the respective districts spoken of in those rules, and a consideration of the many and complex circumstances affecting the drainage of marshes will show, it is believed, that it is improper, perhaps forever impossible, to lay down rules for finding the size and position of tidal drainage sluices.

In our case this size was at first assumed to be 8 feet vertical by 10 feet horizontal, with the bottom on grade 4. (See Fig. 2, cross-section 1.) The simplest formula for the discharge of such a sluice would be $Q = A c \sqrt{2 g h}$, in which

Q is the quantity discharged in cubic feet per second.

A is the sectional area of the submerged orifice in square feet.

h is the head on the orifice in feet.

c is a co-efficient which, according to page 31 of Samuel Downing's Practical Hydraulics, 2d edition, is probably about 0·98.

g is the velocity acquired by a body at the end of the first second of its fall in a vacuum which, in our case, for the level of the sea and latitude 42° 30′, would be, in feet, 32·1616, according to the table given in Francis' Lowell Hydraulic Experiments.

The above formula is incorrect for small heads—in our case probably by some 5 or 6 per cent.—but was adopted on account of its simplicity. To render it more approximate, however, and give the results on the safe side, the effective section of the sluice was assumed to be only 8 feet by 9 feet, instead of 8 feet by 10 feet, the co-efficient c at the same time being taken = 1.

To resume then our calculation, we shall find that from $9^{h.}$ to $9^{h.}$ $30^{m.}$ A. M., there will be discharged through the short rectangular pipe (the sluice) of 8 by 9 feet, under a head of 0·34 feet, in 1800 seconds (half an hour), a quantity of water which, taken from

the surface of 2 million square feet (the area of the river), would lower the same $\frac{72\sqrt{64{\cdot}3232 \times 0{\cdot}34 \times 1800}}{\text{two millions}} = 0{\cdot}303$ feet. During the same time, however, we have had the constant rise of 0·176 feet per half hour to contend with; the actual fall has therefore been only $0{\cdot}303 - 0{\cdot}176 = 0{\cdot}127$ feet, or, since we started at 9 o'clock with the water on the inside on grade 5·40, it will be at $9^{h.}\ 30^{m.}$ on grade 5·27. This can be shown graphically by drawing the line H I between $9^{h.}$ and $9^{h.}\ 30^{m.}$ At this time the tide descends from 5·06 to 4·40, according to the adopted tide curve. We start, therefore, at $9^{h.}\ 30^{m.}$ with a head of $5{\cdot}27 - 4{\cdot}40 = 0{\cdot}87$ feet. Making now the same kind of calculations as previously, we shall find that at 10 o'clock the water stands on the inside on grade 4·96, and so on.*

Table I gives the data and results of all these differential calculations from the time that the tide-gates shut at 5 o'clock A. M. to keep back the fresh water then standing on grade 4, until their next closing at 3 o'clock P. M. with the water then standing on the inside on grade 1·77, all of which is also shown on the accompanying diagrams. The headings of the different columns will sufficiently explain their meaning: column 4 giving the mean velocity of efflux at the different times is interesting, and may also be of utility in designing such works—this latter more especially as regards its determination of the maximum velocity to be expected.

The final result of the examination has therefore been that, under the most disadvantageous circumstances the water will drain down $4{\cdot}0 - 1{\cdot}77 = 2{\cdot}23$ feet on the inside between two closings of the tide gates. Had the gates shut at the close of the investigation with the water on the inside standing where we started, on grade 4·0, it would have shown, that for the duty adopted as devolving upon the sluice, it was just large enough; as it is, we conclude that it is larger than necessary, and try again with another section of sluice, in another position. It is proper to notice here that in the above calculation there is an error, arising from the fact that inasmuch as the top of the sluice is on grade + 4., the water does not fill the same after about $11^{h.}\ 10^{m.}$ A. M., as will be seen from the diagram. The efflux becomes then of a somewhat complicated nature. It is

* Had we taken into account the variations in the amount of surface inside the river banks previously alluded to, it would have entered into each partial calculation in changing the value of the *rise* for that half hour, which would have been 0·176 near the top, and more than this when the water level is on the lower grades.

TABLE I.—*Dotted line Curve on the Diagram.*

Time of the beginning of the several intervals or differentials of time.		Time of the Ending of the several intervals or differentials of time.		Height of the water on the Outside during this interval from the adopted tide curves.	Height of the water on the Inside at the *beginning* of this interval from the curve or using the formula: $Q = A\sqrt{2gh}$.	Difference of level between the water on the inside and outside acting during this interval.	Mean velocity of efflux during this interval.	REMARKS.
A. M. or P. M.	Hours and Minutes.	A. M. or P. M.	Hours and Minutes.	On grade.	On grade.	In feet.	In feet per second.	
A. M.	5·	A. M.	5·	4·	4·	0·	0·	The tide gates shut at this time.
"	5·	"	5·30	4·40	4·			
"	5·30	"	6·	5·05	4·18			
"	6·	"	6·30	5·55	4·35			
"	6·30	"	7·	5·96	4·53			
"	7·	"	7·30	6·22	4·70			
"	7·30	"	8·	6·23	4·88			High tide.
"	8·	"	8·30	6·04	5·06			
"	8·30	"	9·	5·60	5·23			
"	9·	"	9·30	5·06	5·40	0·34	4·677	Inside high water; the tide gates open at the *beginning* of this interval.
"	9·30	"	10.	4·40	5·27	0·87	7·481	
"	10·	"	10·30	3·75	4·96	1·21	8·822	
"	10·30	"	11·	3·17	4·56	1·39	9·456	
"	11·	"	11·30	2·62	4·12	1·50	9·823	Max. velocity of efflux.
"	11·30	M.	12·	2·20	3·66	1·46	9·691	
M.	12·	P. M.	12·30	1·92	3·21	1·29	9·109	
P. M.	12·30	"	1·	1·80	2·80	1·00	8·020	
"	1·	"	1·30	1·68	2·46	0·78	7·083	
"	1·30	"	2·	1·60	2·18	0·58	6·108	
"	2·	"	2·30	1·54	1·96	0·42	5·198	Low tide.
"	2·30	"	3·	1·64	1·80	0·16	3·208	
"	3·	"	3·30	1·87	1·77	.....	.....	Inside low water; the tide gates close at the beginning of this interval.

probably nearer "the efflux over a weir prolonged on the down stream side, by an open rectangular canal of the same width as the weir," than any other given case of efflux that has been experimented on, so far as they are within the knowledge of the writer. Such experiments are given in Lesbros' Expérience Hydraulique, and on p. 488, Table 42, column headed Fig. 15, are the co-efficients which would probably apply to the case under investigation.* There are reasons for and against the probability of their application to the case in hand. Lesbros' experiments were conducted on a small scale, the length of his weir being only about 8 inches; this would probably make his co-efficients smaller than they should be for our case. Hence, in using them, we remain on the safe side. Then, again, the end of the exterior rectangular canal in his experiments discharged freely into the air, whereas in our case it will discharge into a bay, which again empties into the ocean, about $\frac{1}{4}$th of a mile from the site of the proposed sluice. As, however, the velocity of the water at low stages of the tide is always very great—some 5 or 6 feet per second—in the lower reaches of the river, and because the level of the water in this bay depends mainly on the state of the tide in the ocean, the two cases may perhaps be considered parallel.

(To be continued.)

ON THE DRAUGHT, HEIGHT AND AREA OF SMOKE PIPES, ETC.

By John Lowe, First Asst. Eng., U. S. N.

While attached to the Asiatic Squadron, this subject was presented to the writer's mind in a practical way. One of our vessels had a poor draught, and these investigations were undertaken to find how much addition to the smoke-pipe would produce a given result. As there is much that is new, perhaps they may not be uninteresting to the readers of the *Journal.*

If air is forced through an orifice, with a pressure equal to the weight ($w\,h$) of a column of air (h) feet high; it will issue therefrom with the same velocity (v) that a heavy body acquires in falling from the same distance (h) feet.

* They are also given, in part, in the latest American translation of Weisbach's *Mechanics*, p. 850, column A.

That is $v^2 = 2\,g\,h$, . . . (Equation 1.)

$g = 32{\cdot}2$ the force of gravity.

To consume per second the required amount of fuel, we require (V) cubic feet of air per second, which passes through the area (a) of air interstices in the grate bars with the velocity:

$$v = \frac{V}{a\,c}, \quad . \quad . \quad \text{(Equation 2,)}$$

c being a coefficient allowing for the difficulty the air experiences in passing through the bed of coal, etc.

This volume (V) of air passing through the fire is heated from the temperature t to t', and following Gay Lussac's law expands in volume from V to V'. That is $V' = V + V\,(t' - t)\cdot 00205$.

The specific gravity then of the gas (as we will call the heated air) is $\frac{V}{V'} = \frac{V}{V + V\,(t' - t)\cdot 00205}$

$$= \frac{1}{1 + 1\,(t' - t)\cdot 00205}, \quad . \quad . \quad \text{(Equation 3.)}$$

Hence if the weight of 1 cubic foot of air is W, the weight of 1 cubic foot of gas is $\frac{W}{1 + 1\,(t' - t)\cdot 00205}$; the preponderance P of the air over the gas is per cubic foot $P = W - \frac{W}{1 + (t' - t)\cdot 00205}$ and the height H of the stack is the number of the preponderances whose total must become— $P = W\,h$.

Hence $H = \frac{W\,h}{P}$, or substituting in the last equation

$$H = \frac{W\,h}{W - \frac{W}{1 + (t' - t)\cdot 00205}}$$

$$H = \frac{h}{1 - \frac{h}{1 + (t' - t)\cdot 00205}} \quad . \quad . \quad \text{(Equation 4.)}$$

By experiment $(t' - t)$ that is the difference between the temperature in the stack, and that in the ash pan was found to average 146° Fahr. Hence equation 4 becomes $H = \frac{h}{0{\cdot}2304}$.

We might reduce the entire subject to one complex formula, but for simplicity will have three, namely:

$v^2 = 2\,g\,h$. $v = \frac{V}{a\,c}$, by experiment c is ·005571. $H = \frac{h}{0{\cdot}2304}$

For the consumption of one pound of anthracite 195·45 cubic feet of air is taken to be required.

To conclude. The steps to be taken are: Determine the fuel required to be burnt *in toto* per second, next determine the area of air interstice in the grate bars.

From these we find first V and then $v = \frac{V}{a\ c}$. $v = \frac{V}{a \times \cdot 005571}$.

Next by substitution find $h = \frac{1}{2g} \times \left(\frac{V}{\cdot 005571 \times a}\right)^2$.

Whence $n = \frac{h}{0 \cdot 2304}$.

Lastly, the area of the stack is $A = \frac{a\ V}{112993}$, arising from the same considerations that produce equation 3.

THE PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

[P. A. Engineer, Construction Department, Pennsylvania Railroad.]

(Continued from page 41.)

Store House.—Plate I gives the location of the store house, it being marked 5. It is intended for the reception of all articles which it is necessary to keep in stock for use in the shops. Plate X shows the plan of the first floor, a cross section, and a portion of the side elevation of the building.

It will be noticed that the back portion of the house is used for the storage of wrought iron in bars and sheet iron, and has no cellar. The large doors to this apartment are hung on weights, and open by sliding upwards. The front on the first floor is the store room proper, and contains an office for the storekeeper, and a counter, the sides and centre of the room being conveniently fitted up with the necessary shelving, drawers, nail boxes, &c.

Underneath this portion is a good cellar, having outside and inside entrances, and is used for storage of heavy articles.

There is a second floor extending over the whole building, communicating by a stairway with the first floor, and having also a hatchway for lifting goods, in the floor directly over the first-story entrance.

The building is of brick, with substantial stone foundations, and covers an area of 3085 square feet, the details of construction being on the Plate. The floors are supported through the centre of the building by a row of cast iron columns, with wrought iron I beams extending from the columns to the side walls. The cellar columns are 8 inches at the smallest outside diameter, and of $\frac{3}{4}$-inch metal. The first-floor columns are 6 inches at the smallest diameter, and also of $\frac{3}{4}$-inch metal. The I beams are arranged in pairs, two beams at each position. They are 9 inches deep, weighing 70 pounds per yard, and are connected on top by a plate of boiler iron $\frac{3}{4}$-inch by 8 inches section. The floor joist are 3 by 12 inches section, placed one foot apart, centre to centre; the flooring on the first story being 2-inch yellow Carolina pine, and on the second story 2-inch white pine

The second floor is not lighted by windows, but by a skylight, extending along the ridge of the roof, and shown on the Plate, formed of $\frac{3}{8}$-inch rolled glass. Along the sides of the skylight ventilation is secured by long narrow valves, which may be opened and shut at pleasure by cords attached.

The roof has a one-quarter pitch, and is hipped at the ends. The principals are placed fifteen feet apart, centre to centre, the form of truss and sizes of parts being given on the Plate. The covering is of slate, laid upon close sheeting boards and tarred felt, with galvanized nails, and the cornice to the building is of galvanized iron. The main store room is warmed by steam coils from a boiler used in heating the oil house adjoining.

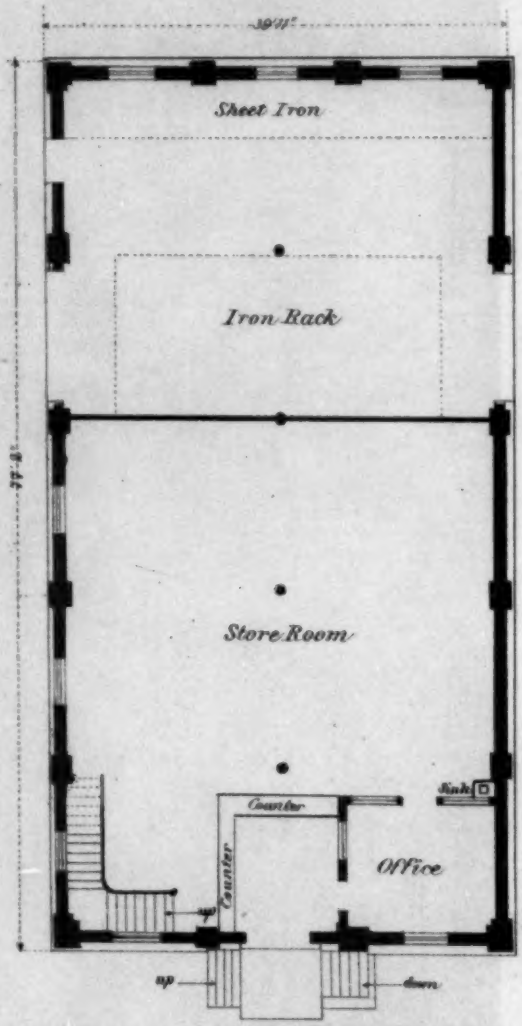
(To be continued.)

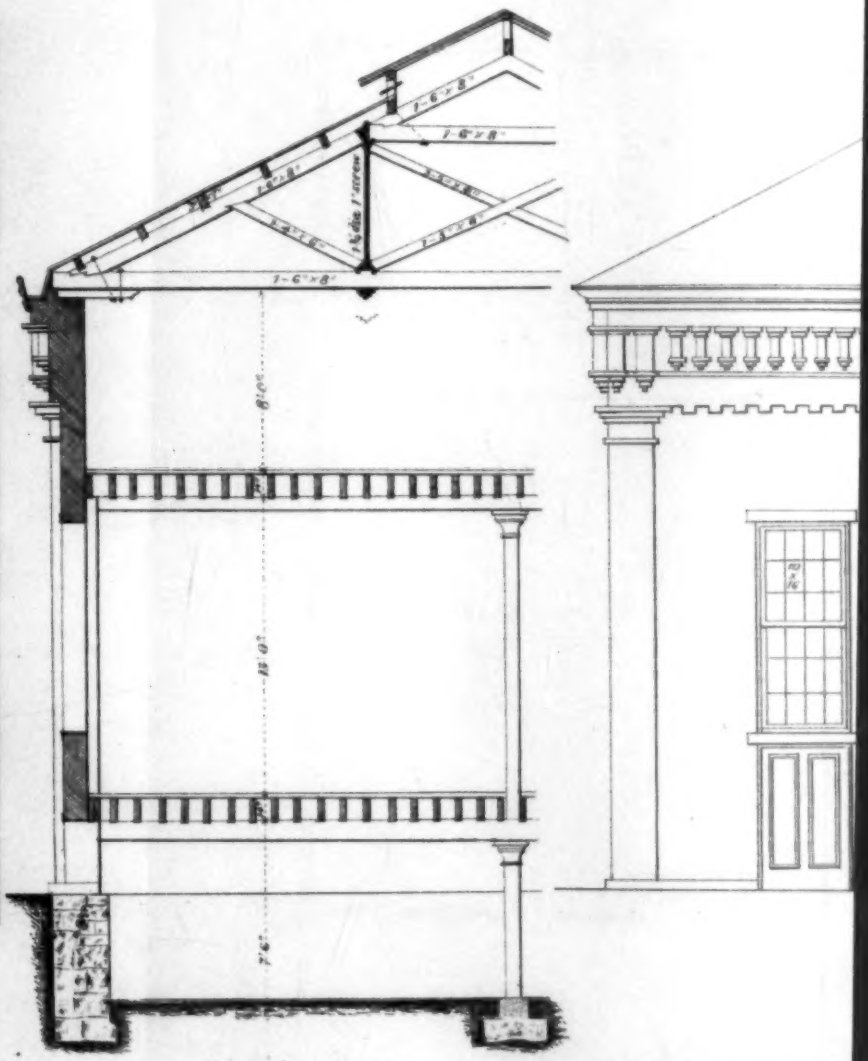
The North Pole Expedition.—By the time this notice appears the exploring expedition under the command of Capt. C. F. Hall will have departed upon its perilous voyage. The scientific department is under the direction of Dr. Emil Bessels, and is furnished with detailed series of suggestions as to its operations from the National Academy of Sciences. It is to be hoped that the expedition may be successful enough to warrant an extension, or at least a continuance of the liberal policy of the government in the cause of scientific inquiry.

Spectrum of Uranus.—Dr. Wm. Huggins has given to the Royal Society an account, illustrated by an engraving, of some spectroscopic observations upon the planet Uranus, from which it appears that its spectrum differs in a remarkable degree from that of the other planets.

Pennsylvania Railroad Shops, West Philadelphia.

Store House.

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sylvania Railroad Shops, West Philadelphia.

Store House.

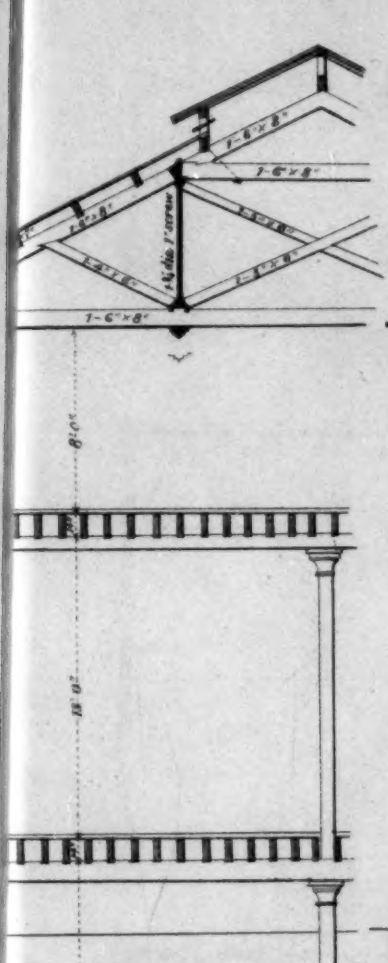


Fig. 2. Cross Section.

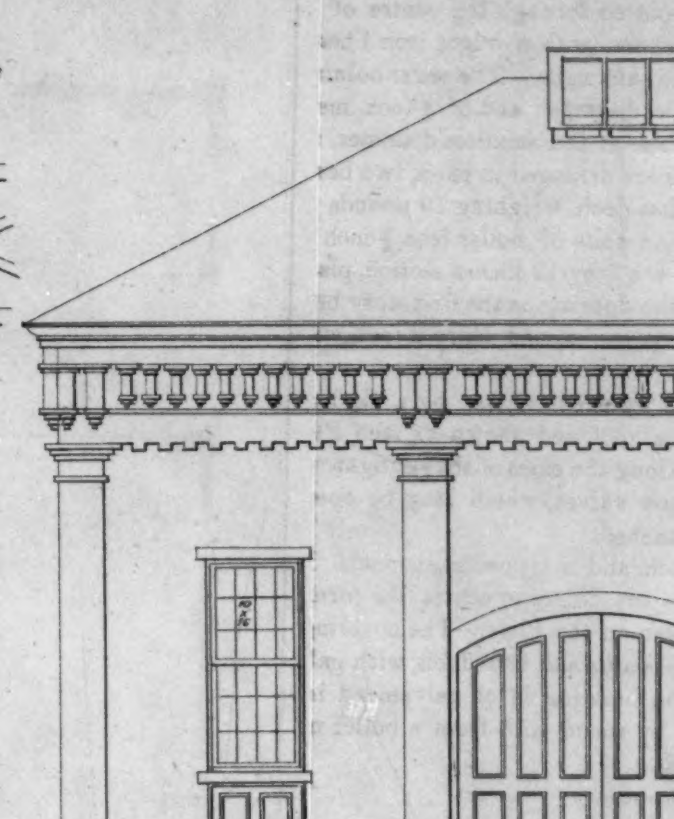
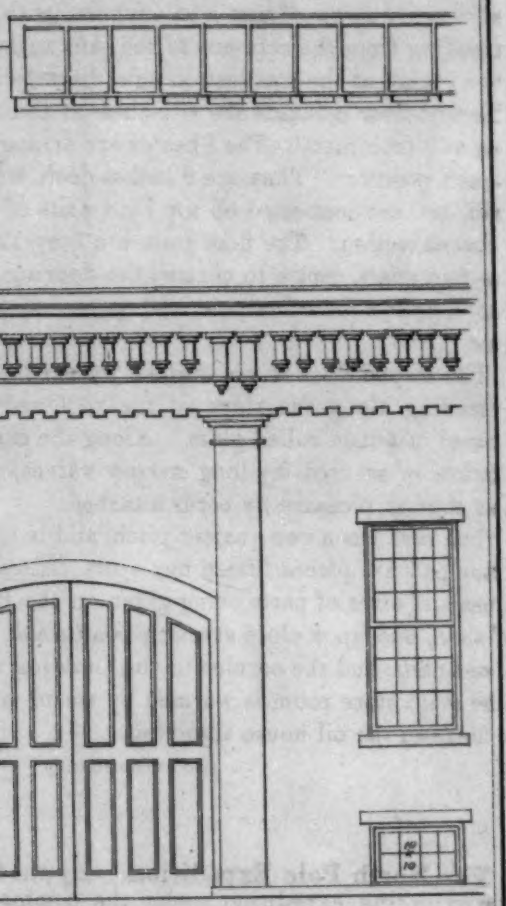


Fig 3 Side Elevat

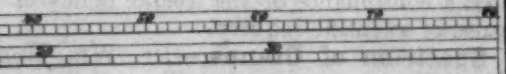
Scale of Feet.

Fig. 1.

Figs 2 & 3.



3 Side Elevation.

Feet.

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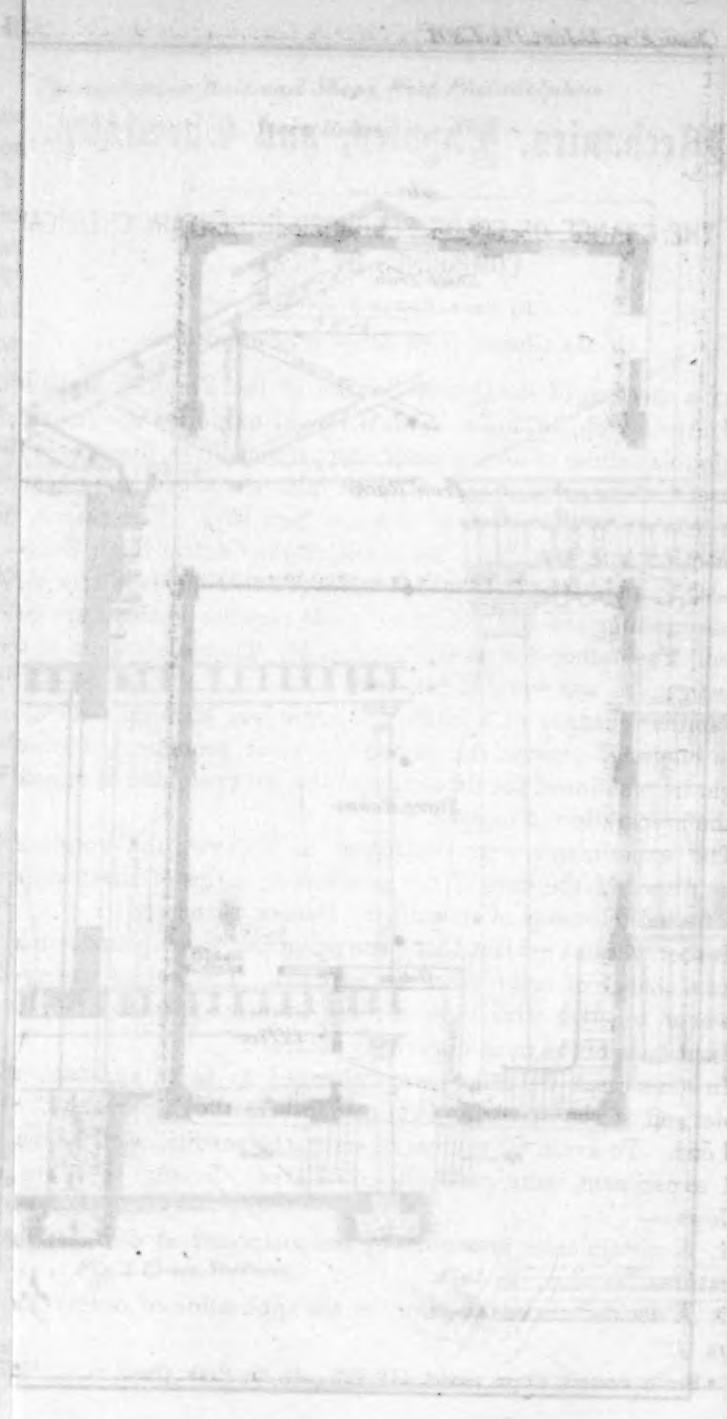

Mechanics, Physics, and Chemistry.

ON THE CHANGE OF COLOR PRODUCED IN CERTAIN CHEMICAL COMPOUNDS BY HEAT.

By Prof. Edwin J. Houston.

Of the Central High-School of Philadelphia.

At a meeting of the Optical Section of the Franklin Institute, held April 26th, 1871, Dr. Wm. H. Wahl exhibited specimens of the double iodides of mercury with copper and silver, discovered by Meusel.* The color of each of these salts is changed in a remarkable manner by the action of obscure heat rays. The author, in connection with Mr. Elihu Thomson, of the Central High School, was led to undertake an extended series of experiments, with a view of ascertaining the law by which these peculiar changes are governed. The author desires to state that Mr. Thomson's share of the investigations was equal to his own.

Familiar changes of a similar though less striking nature, at once suggested themselves, among the most prominent of which, might be mentioned the darkening of the red protoxide of mercury in the preparation of oxygen.

The experiments were conducted as follows: the substances were placed in the state of dry powders on strips of sheet copper, and heated by means of an ordinary Bunsen burner.

It soon became evident that quite a number of compounds underwent a change of color when so exposed. The colors observed, however, together with those already known, appeared at first to present facts of the most discordant nature.

In some cases the colors were changed so as to approach the violet end of the spectrum, while in others they approached the red end. To avoid all sources of error, the conditions of the original experiment were carefully considered. Briefly they are as follows:—

1. A certain color presented by the compound at ordinary temperatures.

2. A decided change of color, on the application of obscure heat rays.

* Ber. d. deutsch. Chem. Gesell. III. 123. Jr. für Prak. Chem. ii. II. 136.

3. A complete return of the original color on the removal of the heat, and the cooling of the body to its former temperature.

Bodies not presenting all these phenomena were rejected.

The largest class of bodies that was excluded by this method, was that in which a permanent change of color was produced by heat. In this case the change is caused either by the heat being raised to a temperature sufficient to cause a decomposition of the body, by a change from the amorphous to the crystalline state, by a partial sublimation and subsequent deposition of the sublimate, by a change in the crystalline form, or by some other permanent change in the arrangement of the molecules.

Changes in color produced by dehydration were also rejected, as for instance, in the case of the chloride of cobalt, which, when hydrated, is a pale pink, but when anhydrous, a deep blue. Hydrous and anhydrous salts are distinct chemical compounds, and have therefore a different molecular arrangement. A class of cases of a somewhat similar nature was also rejected. Here the change of color was produced by a loss of the water of crystallization, as for instance, the sulphate of copper, which changes from a deep blue to a white.

After these sources of error were removed and quite a number of bodies discovered presenting phenomena fulfilling all the requirements of the original experiment, the law became evident. *In every case the color in its change approached the red or heat end of the spectrum.* Not a single exception to this law was observed.

Before stating the explanation of the way in which these changes are produced, a few words in reference to the relation existing between light and heat may be necessary. That light and heat are produced by a vibratory motion of the molecules of bodies, and that they differ from each other, merely in the rapidity of the vibrations of these molecules, the facts presented by the science of the present day, leaves scarcely room for doubt. A hot body differs from another cooler than itself, not in virtue of any peculiar substance or fluid, which it possesses, but simply in the fact that its molecules are in more rapid motion. Increasing the temperature of a body is equivalent to increasing the rapidity of the vibration of its molecules. As the body is made hotter, its molecules vibrate more and more rapidly, until finally a *red heat* is obtained, and light is emitted along with the heat. Now we know that a ray of white light, popularly speaking, is a mixture of seven different kinds of

rays, viz., the colors of the solar spectrum. Moreover, we know by actual measurement, that these colors, in the order of the number of vibrations required to produce them, commencing with the least, are as follows: red, orange, yellow, green, blue, indigo and violet, those of the violet being about twice as rapid as those of the red.

If then light differs from heat, merely in the fact that the molecules of a body emitting light, are in more rapid motion than those of a body emitting heat, when that rapidity in the vibrations of the molecules of a hot body is reached, that it commences to give out light along with the heat, the color first emitted should be red, since that color is produced by the least number of vibrations per second, and the colors which successively appear should be orange, yellow, green, blue, indigo and violet, until finally, these by their intermixture produce white light, and the body becomes *white hot.* These considerations are fully sustained by the beautiful experiment of Draper, who viewed through a prism, the light emitted by a platinum wire, heated by a current of dynamical electricity. The color which first appeared was red, and then successively, orange, yellow, green, blue, indigo and violet, or more accurately when the platinum wire became white hot, it gave a continuous spectrum from the red to the violet.

The boundary between heat and light then, is found at the extreme end of the red of the spectrum. It is evident that though the range of the spectrum must vary with the sensibility of the eye of the observer, that is that the heat vibrations will become light vibrations sooner to some eyes than to others, yet in all cases the color first observed will not be a pure red, but a dark brown; a color produced by the mixture of black, or the absence of color, with the few red rays first emitted.

It should be borne in mind that the arrangement of the spectrum into seven colors is merely a matter of convenience. In point of fact there is an almost infinite variety of tints. The red, for instance, is merely taken at the mean of the dark red and the orange-reds, and so for the other colors.

Remembering these preliminary considerations a fuller statement of the law of the changes may now be given.

In all cases in which the color of a body is changed by the application of heat, and the original color regained on cooling, the nature of the body being in no wise altered, the character of the change is as follows: the addition of heat causes the color to pass from one of a

greater to one of a less number of vibrations; the abstraction of heat from one of less to one of a greater number.

In accordance with this law, violets are changed by heat into indigo-violets or indigoes, indigoes into blues, blues into bluish-greens or greens, greens into yellowish-greens or yellows, yellows into orange-yellows or oranges, oranges into orange-reds or reds, and finally reds into brownish-reds or blacks; by cold the inverse order is observed. In many instances substances were noticed that ran down the scale two or more colors; for example, the green iodide of mercury, which passes from yellowish-green through the yellow, and orange to the red.

Among the most sensitive substances noticed, are the following, arranged by their colors in the order of the spectrum.

REDS.—*Ferro-Cyanide of Copper.*—Color at ordinary temperature, mahogany-brown; darkens by heat to brownish-black, original color returning slowly on cooling.

Brown-Red Sulphide of Antimony.—Kermes Mineral.—Color brownish-red; changes to darker brownish-red.

Anhydrous Sesqui-Oxide of Iron.—Color, brownish-red; changes to dark red, brown, brownish-black and black at a temperature greatly below a red heat.

Sub-Iodide of Copper.—Color, dark red. The changes presented by this substance are very remarkable. On the application of quite a low heat it changes to darker-red, and afterwards to a brownish-red, brown, brownish-black and finally almost a black. The return to its original color on cooling is rapid.

Proto-Sulphide of Mercury.—Vermilion.—Color, bright red, or vermilion; darkens to brownish-red.

Sub-Chromate of Lead.—Color, red; changes quite readily to dark red and brownish-red.

Red Oxide of Lead.—Red Lead.—Color, red; changes readily to dark red.

Bi-Chromate of Potassa.—Color, red; changes to dark red. The change in this case is best observed by heating a small crystal of the salt.

ORANGES.—*Bi-Sulphide of Arsenic.—Realgar.*—Color, when pulverized, orange-red; changes to red, dark-red and brown; returns readily.

Protoxide of Mercury.—Red Precipitate.—Color, orange-red; changes to red, dark red and brownish-red.

Iodide of Lead.—Color, orange; changes to darker orange, orange-red and red.

Oxalate of the Protoxide of Iron.—Color, light orange; darkens. In this case the heat must be quite low, as the substance is readily decomposed.

YELLOWS.—*Chromate of Lead.*—Color, yellowish-orange; changes to orange, orange-red and deep orange-red.

Sub-Sulphate of Mercury.—Turpith Mineral.—Color, yellow; changes to orange-yellow, orange and orange-red.

Chromate of Baryta.—Color, yellow; changes to orange-yellow.

Bi-Sulphide of Tin.—Mosaic Gold.—Color, brownish orange-yellow; changes to a dark red very nearly approaching a black; quite sensitive.

Ter-Sulphide of Arsenic.—Yellow Orpiment.—Color, orange-yellow; changes to deep orange-yellow, yellow, orange-red and red.

GREENS.—*Sub-Iodide of Silver.*—Color, greenish-yellow; very sensitive; changes first to an orange-yellow, and then to a deep orange.

Sub-Iodide of Mercury.—Green Iodide.—Color, yellowish-green; more sensitive than the preceding; changes to a yellowish-green, and then successively, to an orange-green, reddish-orange, red, and brownish-red. These changes succeed each other very rapidly. They may be best observed by heating at once up to the brownish-red, and noting the changes of color that occur as the body cools.

In all the above cases the original color is fully regained on cooling.

The substances named are by no means all that have been observed to come under the law. Quite a number of other compounds have been noticed; but none of them are as sensitive as those already mentioned. In no case, however, has any compound been found of the color of blue, indigo, or violet, that, in the solid state, undergoes any decided change whatever, on the application of a temperature short of that producing, either a decomposition, or a permanent change in the arrangement of its molecules. Nor is this fact contrary to what might be expected. Near the heat end of the spectrum, where the difference between the light and heat vibrations is not so great, we might reasonably expect the particles of a solid to be influenced by each, and to accept a motion which should be a mean of the two, but when we get as far in the spectrum as the blue or indigo, the greatest heat that we can intermingle with the

blue or indigo, even if pushed to the point of incandescence, would be but dull red. Now long before this temperature is reached, most bodies would undergo decomposition, and were this not the case, even then, we could hardly expect the particles of a solid, trammelled as they are in their freedom of motion by the force of cohesion, to accept a mean of two kinds of vibrations, which differ so greatly in their wave lengths. Still it must be borne in mind that solids differ very greatly from each other in the freedom of motion of their molecules, and it is not improbable that a number of solids as high in the scale of color as the blues, indigoes or violets, may eventually be found conforming to the law.

A few very significant facts were noticed in this connection in the case of two pure white substances, viz., the oxides of zinc and of tin; their behavior is as follows:

Oxide of Zinc. Nihil Album; color, white; changes on the application of heat to a scarcely perceptible bluish-white, green and yellowish-green. Does not entirely return on cooling though it resumes nearly its original color.

Oxide of Tin; color, white; here the range is more remarkable. It changes first to a pale-green, then to a decided yellowish-green, and even runs as far down the scale as orange and reddish-orange: returns on cooling to a greenish-white.

These two substances have not been included in the regular list of solids, as they fall somewhat short of the conditions of the original experiment. They conform sufficiently to it, however, to call attention to their behavior.

Experiments were also made on solutions of various solids. As a general rule, it has been found that a substance in solution is more sensitive to the action of heat, than when in the solid state. This, indeed, should be so, as the action of the solvent is simply, by its adhesion for the solid, to separate it into very small particles and to give them much greater freedom of motion. Solids in solution have been found, as high in the scale as the violet, which conform perfectly to the law.

These experiments were conducted as follows; the solution was made of the required strength and then divided between two thin glass test-tubes, of the same size and thickness. They were then held, side by side, between the eye and the light, and carefully compared by transmitted light. If any difference in tint was observed, the solutions were poured together and again thoroughly mixed.

If any difference still existed on again dividing them between the two test tubes, one of the tubes was rejected as differing in thickness or color from the other, and replaced by another until exactly the same tint was obtained. It will readily be seen that these precautions were necessary, in order that the results obtained should not be equivocal. One of the solutions was heated in a Bunsen burner, and the change carefully noted by comparison from time to time. Of course the highest temperature was limited to the boiling point of the solution under the pressure of the atmosphere. In many cases, however, decided changes were observed long before even this point was reached. No experiments were tried on temperatures obtained by boiling under high pressures in confined glass vessels, though there is every reason to believe that by these means splendid results would be obtained. It is purposed, if time allows, to pursue the investigation in this direction, at some future day.

Of course, in all cases where the color did not entirely re-appear on cooling, the experiment was rejected.

The solvent used was water. As the color of a solid in solution varies with the strength of the solution, it will be understood that in all cases the amount of solid dissolved was that requisite to produce the tint described.

The following are among the most sensitive substances noticed.

REDS.—*Rose Aniline;* solution of a strength sufficient to produce a decided red; darkens perceptibly on the application of a boiling heat.

Decoction of Logwood; solution of a deep red; darkens on the application of heat.

Chloride of Cobalt; color of solution, pinkish red; changes to a darker pinkish red.

Sesqui-Sulphate of Iron; color of solution, light-red; changes to brownish-red.

ORANGES.—*Chromic Acid;* color of solution, reddish-orange; changes to an orange mixed with a greater amount of red.

Bichromate of Ammonia; color of solution, orange-red; changes to a pure red.

Sesqui-Chloride of Iron; color of a weak solution, orange-red; very sensitive; changes to red and brownish-red.

Bi-Chromate of Potassa; solution of an orange-red; changes to a red.

YELLOWS.—*Sesqui-Nitrate of Iron;* color of solution, brownish yellow; changes to brownish red.

GREENS.—*Ferro-Cyanide of Potassium;* solution of a yellowish green; changes to a yellow.

Chromate of Potassa; solution of a yellowish-green; changes to a yellow.

Nitrate of Nickel; solution, pale-green; changes to pale yellowish-green.

Sulphate of Nickel; solution, green; changes to yellowish-green.

BLUES.—*Chloride of Copper;* color of weak solution, bluish-green; changes to a very decided yellowish-green. This substance is quite sensitive, the color returning rapidly on cooling.

Sulphate of Copper; solution of a decided blue; changes to a very decided green at the boiling point of the solution. Returns to its original color rapidly on removal from the heat.

VIOLETS.—*Ammonio-Oxide of Nickel;* solution of a violet-blue; changes to a light blue; returns fully on cooling, and cannot therefore be attributed to any loss of ammonia.

Solution of Litmus; color, violet; changes to an indigo-blue.

It may be objected that the substances noticed do not present as great a range of changes as those observed in solids. It must be remembered, however, that the temperature in no case differed much from the ordinary temperature, being never much greater than 220° F., while in the experiments with solids the temperature was often more than three times as great. We feel sure that experiments with liquids at higher boiling points, will show substances running down the scale much further than the observed solids.

The Action of Cold.—It would appear from the law already stated, that the color of a body is affected by its temperature, and that in proportion as this temperature is raised, the color is lowered; moreover, considering the color emitted by the body at its higher temperature, the color is always raised in the spectrum as the body cools. For example, take the case of the green iodide of mercury, which, as before mentioned, is yellowish-green at ordinary temperatures. By the action of heat, its color is successively lowered through the yellow, orange and red, which latter is reached at the maximum temperature of exposure. Cool the body from this point, and its color will become orange, yellow, and yellowish-green, respectively.

Now, the same reasoning that applies to the cooling of the body

from this higher temperature, should also apply, though not with equal force, to its cooling from any temperature, such, for instance, as that of the place in which the body is situated. The color emitted by a body at any temperature, is always lower than it would be were it not for the intermingling of the heat vibrations. Remove it as much as possible from the influence of these vibrations, or in other words, cool it, and the emitted light must be of a higher pitch or color. It would appear then, that as the effect of raising the temperature of a body above its ordinary temperature is, to lower the pitch of the emitted light, so cooling it below that temperature, must be to raise the pitch. The raising, however, would hardly be as great, proportionally, as the lowering. As we recede from the boundary of the heat and light vibrations, we lessen the chance of their producing by intermingling a resulting mean vibration.

With a view of testing the truth of these theoretical considerations, experiments on the action of cold on substances in both the solid and liquid condition were made.

Solids.—The reduction of temperature was obtained by the evaporation of Ether, Bi-Sulphide of Carbon, or liquid Sulphurous Acid. The liquid was placed in a metallic box, furnished with eight vertical sides. Strips of paper, on which the substances were painted, were pasted on the sides of the vessel. Corresponding strips of paper, similarly prepared, were kept for comparison. Cold was produced by blowing a blast of air from a small bellows upon the surface of the liquid. The results obtained were somewhat vitiated by the deposition of the moisture of the air on the sides of the metallic vessel. This difficulty was obviated to some extent by having the paper slip, kept for comparison, equally moist. The results, which are open to this objection, were as follows:

Sulphide of Mercury; changes from a bright red to a brighter red.

Bi-Sulphide of Tin; changes from a brownish orange-yellow to a lighter brownish-yellow.

Sub-Sulphate of Mercury; changes from a yellow to a greenish-yellow.

Iodide of Lead; changes from an orange to a lighter orange.

Chromate of Lead; changes from a yellowish-orange to a yellowish-green.

The substances occupying the remaining sides of the vessel did not present any appreciable change.

Liquids.—The experiments with liquids were, with a few exceptions, of an unsatisfactory character. The solvent in most cases was water, and the cold could not safely be pushed lower than the point of maximum density of the solutions. The solutions were prepared in test tubes, in a manner similar to the experiments with heat. The limitation in the application of cold was, in all probability, the cause of the changes not being of a more decided character.

The following are among some of the substances experimented with:

Sulphate of Copper; solution of a pure blue; deepens on the application of cold.

Ferro-Cyanide of Potassium; saturated solution of a nearly pure yellow; becomes tinted slightly with green.

Chloride of Copper; solution of a bluish-green; becomes a more decided bluish-green.

Sesqui-Chloride of Iron; solution, orange-yellow; becomes an orange yellow in which the yellow is more predominant than in the preceding.

Sesqui-Nitrate of Iron; solution, orange-yellow, like the chloride.

Wishing to obtain a solution that could be exposed to a much lower temperature without freezing, a solution of the chloride of copper in ether was prepared. The color was yellowish-green. When exposed to a low temperature by the evaporation of the bi-sulphide of carbon, the color changed very decidedly to a pure green. It is purposed, at our earliest convenience, to pursue these investigations at lower temperatures obtained by means of solid carbonic acid and ether. Meanwhile, we would be much pleased if any investigators throughout the country, who may be using a solution of the solid carbonic acid in ether, would observe the action of intense cold on the etherial solution of chloride of copper, or on any solution of a similar nature.

The law already stated seems now to have been clearly established, both by the number of cases that come under it, and by the fact that, so far, no exceptions have been noticed. It can hardly be urged, with fairness, that all colored compounds should be equally influenced by the action of the less rapid heat vibrations, for the differences presented by bodies, as regards their transparency or opacity to light, or their diathermancy or adiathermancy to heat, clearly indicate a very great difference in their molecular structure, which difference offers reasons amply sufficient to explain why the

colors of some compounds should be more influenced by heat than others. Again, there can be little doubt that more extended observations will increase the great number of compounds already noticed. For, instance, the well known change from red to yellow, presented by the red iodide of mercury, dissuaded us at first from submitting it to an experiment. On a careful trial, however, it was found to illustrate the law, changing to a decidedly darker red up to the temperature requisite to alter its crystalline form.

The theory also receives further support and confirmation from the following considerations.

It is well known that when a yellow and a red substance, which have no chemical action on each other, are mixed together, the resulting color is orange. The explanation is undoubtedly to be found in the raising of the less rapid red vibrations by the yellow, and the consequent lowering of the yellow by the red, the mean, resulting vibration being that capable of producing orange light.

This case, though analagous to the change produced in color by the action of the heat, is not strictly identical with it. In an orange substance, which emits red light when heated, the change is produced as follows; its molecules, while vibrating in periods requisite to produce orange light, are, at the same time, forced to accept the less rapid vibrations of heat. They are unable to do this without lowering the rapidty of the light vibrations, and the emitted light is red. Here, however, the molecules themselves transmit red light to the ether surrounding the intermolecular spaces, which ether in its turn transmits it to the eye for the purposes of vision. Now, in the case of the orange light emitted after the commingling of a yellow and a red substance, as no change other than that of mixture is produced, we must still conceive of the particles of the red and of the yellow substance vibrating in periods requisite to produce red and yellow, and the interference taking place in the intermolecular spaces. Briefly the difference is as follows: In the substance whose color is changed by heat, the *molecules* transmit the changed light directly to the surrounding ether, while in the commingled bodies, the change occurs in the ether surrounding the molecules. The two cases become strictly analagous when we mingle red and yellow light.

In accordance with this view, pure orange and green when mingled should produce yellow; yellow and blue, green; green and indigo, blue; and blue and violet, indigo.

When we come to the boundary of the spectrum on the light side, in other words when we come to the violet, an apparent objection meets us. We know that violet can be produced by the mingling of indigo or blue light with red. That is *two lower vibrations*, and one of them at the lowest extremity of the visible spectrum, produce by their mingling a resultant *higher vibration*, a fact certainly improbable, and seemingly at variance with theory. It must, however, not be forgotten that the violet of the spectrum marks not the limit of the etherial vibrations, but merely our power of appreciating them. The existence of higher vibrations is shown by the actinism of the spectrum, or the effect in producing chemical decomposition, existing some considerable distance beyond the violet. In fact, Herschel, by concentrating this invisible light beyond the violet, succeeded in rendering it visible, and gave its color the name of lavender. This light is of a pale red, inclining to a tinge of violet.

The explanation is now simple. The violet of the spectrum is not produced by the mingling of the indigo or blue with the remoter or lower red, but with that of the higher red or lavender. Indeed, we are strongly led to the belief in the existence of a spectrum beyond the visible spectrum, whose colors, could the eye be trained to appreciate them, would be lighter tints of the lower color. This spectrum would then begin with a paler, shriller, higher red, which we actually have in the lavender. The next, which will probably some day be rendered visible, would be a paler, shriller, higher orange; and so on through the yellow, green, and the other colors.

The analogy of the less rapid vibrations requisite to produce sound is in strict accordance with these considerations. Take, for instance, the note C of the natural gamut; it requires for its production, say 128 vibrations per second; if we increase the rapidity of the vibrations to 144, we get the next higher note, or D; at 160 vibrations, E; at 170⅔, F; at 192, G; at 213⅓, A; at 240, B; and at 256, or just twice the number of vibrations requisite to produce C, we get a higher note, which we call C′, which, though it differs from C in its pitch, and probably in its timbre, still bears to it in many respects a striking resemblance.

The visible range of colored notes also constitute one octave, viz: red, corresponding, say, to C; and then orange, yellow, green, blue, indigo and violet, corresponding respectively to D, E, F, G, A and B. The octave, or the lavender, corresponding to C′, can only be appreciated by the eye under favorable circumstances.

It is most probably more than a mere coincidence that the interval between the lower and the higher red, which is $\frac{1}{2}$, is exactly the same as the interval between the higher and the lower c. Indeed, calculations we have made, show a remarkable similarity in the intervals between the different colors of the spectrum, and the notes of the natural gamut with which we have compared them.

The same reasoning applies to the colors of the spectrum beyond the red, on the heat side, the next color to which, could it be appreciated by the eye, would probably be a very dark reddish-violet, or a purple. In confirmation of this view, we have noticed that some reds, in turning into browns and blacks, possess a slight tinge of purple.

THE SUN.

A Course of Five Lectures, before the Peabody Institute of Baltimore.

By Dr. B. A. Gould.

(Continued from page 66.)

In 1852, nine years after Schwabe's discovery of a period in the spottiness upon the sun, Prof. Wolf, of Berne, was led, by careful study of the observations in connection with ancient records, to a modification* of the length of the period, which Schwabe had roughly fixed at about ten years. The large spot which Keppler saw before the discovery of telescopes and took for the planet Mercury, in 1607, indicates that the time of maximum could not then have been far off, and since Fabricius saw the sun at times without spots, his observations must have been during a period of minimum spottiness. Critically examining the various observations of Galileo, Scheiner and others in the early days, and thus following the records of different observers for about two and a half centuries, he found† that the total series was best represented by a period of $11\frac{1}{9}$ years. Only a year earlier than these researches of Wolf, Lamont in Munich had found out the remarkable fact‡ that the variations of the earth's magnetism are subject to a periodic recurrence

* *Astron. Nachrichten*, XXXV, 369.

† *Neue Untersuchungen über die Periode der Sonnenflecken, etc. Mittheilungen d. Berner naturf. Gesellschaft.* 1852.

‡ *Ueber die 10-jährige Periode, welche sich in der Grösse der täglichen Bewegung der Magnetnadel darstellt.*—Pogg. Annalen, LXXXIV, 572.

once in about 10½ years, and Wolf succeeded in proving that the very period of 11⅛ years, which he had found to be the most probable one for the sun-spots, answered also for the variations of terrestrial magnetism better than that found by Lamont himself.* Thus it became evident that the interval at which the phenomena periodically repeat themselves is the same for solar spots and for variations in the direction of the magnetic needle; or, at least, that any difference in the length of the two periods is too small to be yet detected—and it is but natural that this so remarkable coincidence should suggest an identity of cause. Whether this is really so or not, we have no other evidence to decide. Almost simultaneously with Wolf's announcement, two other investigators, Gautier† in Geneva, and Sabine‡ in London, independently called attention to the similarity of the periods for the two phenomena, both in their duration and in the epochs of their greatest and least intensity. It must now be accepted as a fact that the maximum number of sun spots occurs in the same years with the greatest variation of the declination of the magnetic needle, and *vice versa;* so that the observation of one of these phenomena serves to indicate the facts concerning the other.

Nor is this all that has been learned concerning the spot-period; for besides this period of the ninth of a century in their frequency, more minute investigation showed a regular variation in this period itself, by which once in seven or eight periods the maximum frequency occurs sooner, by two or three years, than this law would indicate—the preceding interval being too small, and the following one too large by this amount. The cause of this periodic fluctuation in the period is known as little as that of the period itself, nor have the observations of terrestrial magnetism extended over a sufficient series of years to make it manifest where any similar phenomenon is exhibited there also; other interesting and singular researches have been made, which it has been claimed establish a connection between the amount of spottiness in the sun and the positions of the planets. These inquiries, began by Wolf and Schmidt, have been continued on an extended scale at the Kew Observatory, and these investigators believe that they have found a close relation between the positions of Venus and Jupiter, and probably also the

* *Berner Mittheilungen*, 1852, p. 182, July 31.

† *Bibliotheque Universelle*, July and August, 1852.

‡ *Philosophical Magazine*, Sept., 1852 (presented to Royal Society, March, 1852.)

Earth, on the one hand, and the amount of sun-spots on the other. Indeed, it is maintained that the position of the spot-zone upon the sun's surface is itself subject to periodic changes, dependent upon the latitude of Venus. There is no time for us to enter into any discussion of this subject at present; but I think I may say that although the various arguments have been presented with great ability, and much that is plausible has been adduced in their favor, they have not yet found general acceptance with astronomers. Again, it has been maintained that auroras and magnetic storms, which appear to be only different manifestations of the same phenomenon, are more numerous in those years when solar spots are most abundant, and comparatively infrequent in other years. The same, too, has been said of earthquakes. But all these ideas can scarcely claim any higher rank than that of suspicions or surmises; certainly they are far from being proved or from finding assent among scientists as a class. The same is the case with the inferences concerning a curious occurrence which you will find described in some popular books, and which took place on the 1st of September, 1859. It was seen by two English observers, some 20 or 25 miles distant from each other, Messrs. Carrington at Red Hill and Hodgson at London. The first named gentleman saw* two very bright patches of light break out in the midst of a large group of spots, and traversing in 5^m. a space of 35,000 miles, fade rapidly away as two dots of light, before they had reached the margin of the group. The other described† a single very brilliant point of light like a star, which illuminated the upper edges of the neighboring spots and streaks, and after about 5^m. disappeared instantaneously. This curious phenomenon was without any precedent on record, and Mr. Carrington, calling at the Kew Observatory a day or two afterwards, found that at nearly the same time the self-registering magnetic instruments there had experienced a sudden disturbance. To this interesting coincidence he naturally gave publicity, although without any such unphilosophic inference as, that because the phenomena were simultaneous they must be connected in causation. Still, the temptation to make a striking inference seems to have been too strong to be resisted by sundry writers of popular treatises, and you will find in many publications in our own language such statements as that the two phenomena took place at precisely the same instant, and that their sudden disturbance in the sun sent its instantaneous

* *Monthly Notices Royal Astr. Soc.*, XX, 13. † *Ibid.*, XX, 15.

influence to the farthest recess of our system. These are statements unsupported by the record. The disturbance of the magnetic instruments appears to have taken place at $11^{h.}$ $15^{m.}$ A. M., lasting about three minutes in its vigorous action, and about $7^{m.}$ more before it abated.* The outbreak of the bright patch on the sun was not until $11^{h.}$ $18^{m.}$, and in $5^{m.}$ Greenwich time all traces of it had disappeared. The magnetic perturbation was only one of many minor fluctuations during a great magnetic disturbance and series of auroral displays, which continued from nearly four days previous until more than 5 days subsequent to the solar phenomenon. Bearing these facts in mind, it would seem that other indications of some physical connection between the two would be needed to justify the opinion that the near approach to simultaneousness was anything more than a "curious coincidence." The magnificent exhibition of the Northern Lights on the nights of August 28 and September 1, 1859, will doubtless be remembered by many of you. This 9-days series of auroral displays was among the most beautiful, and the accompanying disturbances of the magnetic needle were among the most intense of the last fifteen or twenty years. During a portion of this time the large groups of spots referred to was a conspicuous object upon the sun, and on the day named a somewhat larger amount of area was occupied by spots than on any other during Carrington's series, although the excess was not very great. The magnitude of the magnetic disturbance at the moment in question was not comparable with that on many other occasions during the series, nor would it have attracted notice during the 21 hours' agitation of the needle three days previous, or during the $3\frac{1}{2}$ days of perturbation which set in 18 hours afterwards. As regards the supposed relations between the frequency of auroras and the amount of spotted surface upon the sun, I should add that Prof. Lovering, of Cambridge, has recently published a most elaborate and highly valuable memoir, in which he has made a catalogue of all auroras to be found on record, and has carefully discussed their relative frequency at different times. Although the fact that they are periodic is thoroughly demonstrated by these copious materials, yet no relation whatever is indicated between the auroral period and that of the solar spots, nor indeed does Prof. Lovering find any reason for supposing the two phenomena to be at all connected with each other.

* Stewart. *Philos. Trans.*, 1861, p. 426.

That the total heat of the sun is perceptibly less in those years when the spots are most abundant, appears to be an established fact. Schwabe thinks that those years in which they are least numerous generally afford the largest proportion of clear days, and he also mentions that although he has always used his telescopes in the same way since the commencement of his solar observations, more than forty years ago, the heat concentrated in the focus has never cracked his shade glasses except during those seasons in which spots were comparatively infrequent. And it should not be forgotten that the year in which Pouillet made his measurements of the sun's heat, viz., that beginning June 1, 1837, was almost at the time of the greatest spottiness. A repetition of these measures at different epochs of the spot period is greatly to be desired.

There remains but one point to be considered before passing from this subject of the spots, which may, I fear, have grown tedious to you. It is the question whether there are any special points or regions upon the sun where disturbances of the surface are especially prone to break out. The interest of the question at present is due rather to the zeal with which it has been investigated by many astronomers, and to the wide difference in their conclusions, than to any well grounded uncertainty which now exists upon the subject. Spots have been recorded in N. lat. as high* as 50°, and as far South† as the lat. of 45°, but these are the outer limits unless we accept an ill-substantiated statement of a spot seen at 70° N. The existence of the spot-zone has been known since the earliest observations; and that of the inner equatorial belt within which they rarely occur, and which divides the spot-zone into a northern and a southern half, has likewise been established for some forty years; but the question to which I now allude is whether there are within the spot belts, particular points at which the spots appear to originate more abundantly than elsewhere. The affirmative has been maintained by Peters after study of a very considerable series of observations made at Naples, for the purpose of determining this very question, and even Schwabe thought that some of his observations indicated the existence of one such fixed point; but Carrington's observations indicate the reverse very decidedly. Indeed, now that we know the body of the sun to be at a temperature totally inconsistent with our ideas of solidity, and have every reason to believe it only

* *Proc. Amer. Asso. Adv. Science*, 1855, p. 92.

† Carrington, *Observ. of Solar Spots*, p. 157.

a gaseous mass incapable of permanent inequalities of surface, or local features, and in fact must regard it as demonstrated that even its rotation is that of a yielding and scarcely plastic mass—since it actually moves with different angular velocities at different distances from its equator—the question appears to answer itself; certainly it loses its significance.

We see that, as I have already said, our sun is a variable star, having a period of slightly diminished brilliancy once in about 11⅛ years, and a secondary fluctuation * of this period once in about 80 years. Wolf has compared this form of variability with that of sundry variable stars known to us, and thinks † that in this respect our sun most nearly resembles the star *η Aquilæ*.

In addition to our study of the quantity and intensity of light, two modes of investigating its quality are known to us. One is by discovering in what planes the luminous undulations occur; the other is by determining the proportion of rays of each degree of refrangibility which it contains.

A single beam of ordinary white light—the smallest that can affect the eye—consists by no means of a single ray, but of a multitude of rays so numerous as to baffle any attempt to express them in figures within the range of our appreciation. All the vibrations which constitute a ray, or beam, are at right angles to its direction, or axis; but in ordinary light they take place in every possible plane which passes through this axis, being in all directions around it, so that, coarsely speaking, the shape of what is commonly called a ray of light may be considered as cylindrical—formed by the contour of a multitude of individual rays, situated in different planes, although coincident, so far as their common axis is concerned. ‡ Now, there are various influences which may change the plane of vibration for some of these component rays. One of them is obliquity of reflection, another is obliquity of emission from a solid or liquid surface, and there is a certain angle at which reflection will do it so completely as to throw all the vibrations into one single

* *Astron. Nachrichten*, LXV, 63. † *Ibid* LXIV, 133.

‡ This statement must not be too literally interpreted. What I desire to say is, that a single ray of ordinary white light is equivalent to what we must at present consider as an immeasurably large number of rays, in every possible plane around their common axis; and that each of these plane rays, whatever its actual character, is susceptible of analysis into a countless number of rays of definite refrangibility—comprising, so far as has yet been determined, every possible wave-length between the limits named.

plane, so that a section of the beam of light would be represented no longer by a cylinder, but by a flat bar. This modification of light is called polarization, and there are various optical devices by which it may be tested, and the position of the resultant plane detected. For light which has passed through no crystalline structure, and has not been emitted, at a very oblique angle, from the luminous surface, the existence of polarization is usually an indication that it has undergone reflection, and the degree in which it exists, together with the position of the plane of polarization, may afford valuable information concerning the reflecting surface.

(To be continued.)

PENNSYLVANIA'S ANCIENT SEA.

Lecture delivered before the Franklin Institute, Thursday evening, Jan. 5, 1871.

By Prof. Leeds.

(Continued from page 61.)

The theories which we adopted in the first lecture of the course with regard to the formation of the earth's crust, and of the gradual cooling of the surface, make it necessary for us to ascribe to the sea at that time a temperature considerably higher than that which it has at present. Although there were no such fearful paroxysms then as later when the crust had thickened sufficiently to withstand all minor forces, and only yielded to some vast throe which raised mountain chains above the surface, yet its movements, the oscillations of the crust above and below the sea-level, were probably proportionately more frequent. The increased solvent power of the water and the greater frequency of its contacts with the land; both these causes combined to saturate the ancient sea with saline ingredients.

That no fishes swam along these sandy shores may perhaps be better explained or understood in connection with the composition of the sea at the time the beach was forming. For although whole genera of animals and plants have perished, which, probably were as well able to live now as earlier, yet it is certain that no creature was created prior to the existence of those circumstances which made life endurable. Nay, more, in consideration of the perfect adaptation and harmony which we note everywhere between every

animal and its home, it is not too much to say that no creature was developed before its life would be pleasurable to itself, and that too in the highest degree. To my mind, the fact that no fishes existed in this ancient sea, is evidence that the sea then differed from the present ocean. Differed in the great excess of its mineral and the scantiness of its organic constituents. The growth of fishes does not demand a large quantity of mineral matter—their skeletons of bone forms a moiety of their weight and bulk. Indeed, when the earliest formed fishes appear in the sea, they are found to consist largely of cartilaginous skeletons, demanding little if any limestone or other mineral matter. But their fleshy parts were very greatly developed, and demanded for their sustenance an abundance of vegetable and animal food.

Fishes have done very little in the building up of rock strata. Very frequently they decayed entirely or left no sign except the pattern of bony plate, or fin, or spinal column. They are in no sense to be regarded as rock builders or masons. They are consumers, voracious feeders, and many of them scavengers, removing vast quantities of decaying and decayed vegetable matter from the ocean, assimilating myriads of smaller and less highly organized creatures into their own structure, and becoming themselves the food of bird and beast.

The denizens of the ancient sea appear to have been constructed to subserve very different uses. We are impressed on examining them with the idea that their structure was designed to animate the largest possible amount of mineral matter with the smallest possible quantity of organic. Considered with regard to the animals which lived at this time, and not with reference to the rocks which were then formed, this age is pre-eminently the Age of Mollusks—creatures with shells. Shells are the skeletons of animals with soft bag-like bodies, and serve to support and maintain in position the yielding fleshy parts. But note in the first place, that these skeletons are not placed in the interior as they are in animals of higher organization, not divided up into the finest shafts and scaffoldings consistently with the burden which they have to sustain as in the case of fishes, not filled with great cavities and inflated with air as among birds, not permeated by absorbents and blood vessels and charged to repletion with every variety of duct and vessel capable of urging vitality to the highest, such as we find among animals and especially in man. These skeletons are solid, destitute of tube,

chink or cavity. They are thick and massive, capable of withstanding the attack of foes. Fortified with ribs and buttresses and great spines, resisting the thump of the waves upon the shore or the dash of the storm upon the reef. Many have wide thick hinges, and terminate in huge stony beaks. In some of the brachiopods, the dorsal curves in beneath the ventral of the two valves which form the shell, and leaves but a thin disk very small compared with the bulk of the shell itself, to accommodate the body of the animal. In other great families of the brachiopods, such as the terebratula, spirifer and rhynchonella another device for giving support to the flesh of the mollusk is resorted to but one which equally conspires to exaggerate the proportion of the stony to that of the living and perishable part. They are provided with calcareous supports, running into the body of the animal upon the inside, and curved or twisted or bent up into spirals as the case may be.

These ancient seas were prolific in a vast number of shells, resembling the Nautilus, in which the design to which I have alluded is even more apparent. These animals could never cease building, and were compelled to build a new and larger house for themselves with every year of their existence. Every little while came moving day, when they were compelled to move out of their former habitation and close it up by a wall whose only entrance was a little door, through which they thrust down into the hold as it were a tube or siphuncle, by means of which they might load on or throw off ballast, and sail upon the surface or feed upon the bottom, just as they pleased.

The earliest of these chambered shells, or *cephalopods*, as they are called, were stout, strongly-built fellows befitting their craft as masons, and displaying little in the way of decoration or beauty of shape. Many of them were huge, slightly-tapering cones, a foot in diameter at their broadest part, and stretching twelve or fifteen feet behind the head of the animal; an iron-clad monitor, which, if armed like his descendants, the cuttle-fishes, with ferocious mandibles, must have been a fearful craft to contend with. As time went on these cephalopods changed, until from being the most massive of the molusks some of their successors, as, for instance, the paper nautilus are among the most delicate. The straight *Orthoceras* gave place to the *Lituites* with shell curved like the trumpet with which the Romans were wont to summon the legions to battle. And these again to species more and more closely coiled until the ex-

treme of curvature is reached and the coils meet, as in the Nautilus and Ammonite. Instead of the thick straight wall which the orthoceras built against his former dwelling place, his descendants devised every variety of beautiful arch and vault, and substituted intricacy of pattern and complex architectural devices for the cyclopean masonry of their ancestors. At last the shell is taken away from the outside, and as in the case of the modern cephalopods it is put in the interior, the soft parts enclosing it. And instead of being compact limstone, it becomes, as we see in the cuttle-fish, spongy, and in the squid, even horny in its texture.

I shall merely allude to the vast profusion of other rock-building animals at this era, to the enormous number of corallines and the great size and abundance of encrinites or stone lilies as they are called. But I would call your attention more particularly to one of the most curious of the inhabitants of this ancient sea, and ask you to note how well adapted he was to pile up rock masses. I allude to the Trilobite, of which old-fashioned fore-runner of the crabs, nearly sixty specimens have been found scattered over this sandy beach. His remains, indeed, are present in the greatest profusion—a profusion which is indicative not only of the immense number of individuals which flourished in these seas, but, what is more to our present purpose, of the great strength and solidity of the shell and of its adaptation to rock construction. For the question whether a species of plant or animal shall leave behind some fossil relic of its existence depends vastly more upon the materials of which it is composed, than upon the fewness or multitude of individuals. Consider for a moment the countless millions of insects and worms and birds which populate the air and earth and water at the present time, and have filled every corner of the earth with busy hum and motion in ages that have gone before, yet how few of these leave any token behind. But the tribolite was fortified by a massive buckler upon the head, and defended himself against attacks from the rear by a heavy shield. His eyes looked out from loop-holes in watch-towers erected far above his head. Great plates curved backwards over the cheeks and sheltered his flanks. Young and old, little and big, in every attitude of eating, repose or war, lying prone upon their backs, rolled up into balls so as to bring their tender organs of locomotion within the ramparts of their stony covering, in every stage of embryonic growth, and every period of

prime and decrepitude, trilobites here, trilobites there—these sea-coast rocks are full of them.

In some places these grave-yards of the dead of the ancient sea-dwellers have remained undisturbed, and not even the trinkets of Pompeii and Herculaneum, or the jewels found in Etruscan vases, are more perfect than their every limb and plate. Elsewhere coral, shell and crinoid have been crushed into fragments triturated to dust and compacted into rocks over which we may wander for hundreds of miles, and quarry downward through as many feet, without detecting point or line which may make the vast tomb-stone legible. And if we shrink back appalled at the thought of such utter havoc and destruction, what explanation more comfortable or more reasonable can suggest itself?

Does it help the matter at all to take the consideration of the origin of these limestone rocks away from the naturalist and turn it over to the chemist. To regard these ancient seas not as aquaria, but as precipitating vessels—their contents not as coming from the charnel house, but as refuse thrown from the laboratory of nature. We know, indeed, of springs laden with calcareous matter, such as are found in England and in Italy, such as deposit around their sides coats of limestone, and speedily incrust the birds'-nests and toys that tourists carry away with them as curiosities. But will any number of springs which we might imagine to have opened out upon the bottom of the ancient sea, account for limstone rocks spreading over thousands of miles and of prodigious thickness. And if we attribute the formation of these limestone rocks to evaporation and precipitation, we are compelled to suppose in the first place that these seas were divided by barriers into land-locked basins, and, secondly, that they were so charged with calcareous matter and so deficient in common salt and other saline ingredients that beds of limestone would be formed by precipitation on the bottom unmixed with any of the other numerous chemicals which the seas usually contain.

I have previously spoken of the rapidity with which the coast-line of the ancient sea altered. Limestone succeeds sandstone and sandstone follows shale, and shale is succeeded by limestone again, each kind of rock telling us that a change had taken place in the sea-beach, in the sea depth and oftentimes in the marine plants and animals just prior to the beginning of its deposition. The cold currents from polar regions probably streamed at this era along the

shores of Labrador, New England and probably much further southward. No vestige of reef or barrier along the southern shore remains to render improbable the supposition that the warm ocean streams flowing upward from the equator found their way in this ancient continental sea, tempering and diversifying its climate, and that a primeval gulf stream carried warmth and life to the westward of the Appalachians as now the present gulf stream makes Ireland verdure-clad and Norway habitable. Where the waters were shallow and poured along impetuously, beds of coarser sand and pebbles and gravel were formed. Tranquil bays and greater depths were filled up by fine silt, and were tenanted by brachiopods and other animals, akin to mussel and oyster, that love a muddy bottom. Far out in the open seas, where lines of hill or crater of old volcanoes gradually sinking beneath the surface, or reefs lying beyond the overturning and filth of surge and breaker, in waters pure as those that now lave the atolls of the mid-Pacific or boom along the shores of the Philippines, myriads of polyps plied their self-denying craft. If we could have looked down through waters where such corals grew we should have seen parterres of many shaped cyathopylloids, corallines with the tiniest of cups and vases, looking like the calices of slender flowers. To heighten our enjoyment among these gardens of the sea and to complete the illusion we should have seen crinoids great and small. Some standing on slender stems and others on stout trunks—stems and trunks round, five-sided and many-sided, stems smooth, chanelled, punctured, spined. And as stem and trunk bent or waved to and fro with current and with tide, the stony boughs above rose and fell with their motion. A thousand tentaculæ spread out their tendrils to drink in food and life from the sea.

As empires and dynasties have flourished long, until they seemed firmly rooted in the land, yet growing effete or completing their mission have yielded to hardier races, so among the tribes of plants and animals which we have been considering. There came a time when the ancient dwellers along the sea-beach disappeared, and new tribes ruled over sea and land. When the sandstones ceased forming, the denizens of the strand perished too. A time came when limestone was the dominant, as sandstone had formerly been the prevailing rock material. You can study this for yourselves along the gentle slopes and basin of the great Chester Valley. You can see these long fences built of sandstone, and spring-houses

vaulted with thin broad slabs, and houses and churches erected out of the hardened sand which was the first deposit along the shores of Pennsylvania's ancient sea. In the centre of the valley is everywhere limestone. And if we wonder why these slabs and marbles show few if any traces of the life which once teemed among them, their defaced and mutilated condition gives us a sufficient answer. For these sandstones and limstones that once lay almost if not quite horizontal at the bottom of the sea are now tossed up in sharper waves and crests than we see upon the tempestuous ocean. The sand has been compacted into a glassy mass, the limestone has been converted into crystalline marble. And sometimes, as in the deep quarries at Oaklands, whence the columns of Girard College were procured, after a deep trench has been cut upon one side of a bank of marble, and a long line of wooden wedges has been partly driven in along the bottom, a deafening report like a sudden crash of thunder bears witness to the pressure to which the marble has been subjected for centuries, and the sudden relief of which has caused the explosion. Every long furrow up and down the valley indicates a depression between two such uptilts of the limestone strata. Every knoll or grassy hill of a fold in the rocks higher than others in the vicinage. Terrible have been the deluges which have poured down the southern slopes of the North Valley hills and carried along the crests of the waves of the rocks. Down all the hillside and extending far out into the middle of the valley are blocks of sandstone of such weight and size that nothing short of herculean force could have availed to effect their transportation. The limestone crests have been carried off, too, as the rounded and water worn rocks show, but their more perishable nature as compared with the sandstone has brought about their early destruction and disappearance.

If now we should leave the shores of Pennsylvania's ancient sea, and sail across the Atlantic, we should find a Europe still more unlike the present at this period, than was our own North American continent. Germany and France, Great Britain and Spain are marked only by a few and widely remote islands. Italy and Greece, the first civilized of the countries of Europe had not risen from the Mediterranean. Norway and Sweden probably the last inhabited portions of Europe, were then the only parts complete.

And now farewell to the ancient sea. If aught in our ramble along the shore or sail across its waters has interested you, perhaps, you may turn with me at our meeting, next Thursday evening, a curious eye upon Earth's Wrinkles and Faults. And that you may not fail to see them plainly, I shall endeavor to have a number of them photographed for you.

OBSERVATIONS ON FLUORESCENCE.

By HENRY MORTON, President Stevens Institute Technology, Hoboken, N. J.

I WAS led to observe recently, that the common asphalt used in many of our pavements gave, with alcohol, a faintly yellow solution, which, in a Geissler tube, fluoresced with a clear blue tint, resembling that obtained from the usual acid solution of quinine-sulphate, though less bright and that with turpentine the same substance formed a solution of a dark orange or mahogany tint, which under like conditions gave a green fluorescence like that observed with the tincture of turmeric, but much brighter.

It occurred to me that the green color in both these last named solutions might be due to the absorbing power of the colored liquid, and I therefore decolorized both by filtering through animal charcoal, when I found in fact that both fluoresced blue. It was of course possible, however, that the filtration had removed some substance which had a green fluorescence, and I therefore varied the experiment by examining the light of the fluorescent substances with the spectroscope. If the green tint was due to a true fluorescence, then an excess of green or yellow light should be found in the body fluorescing green, when compared with one fluorescing blue or with the spectrum of the electric discharge in a part of the tube not covered by the solution. If, on the other hand, the green color were due to absorption in connection with a blue fluorescence merely, then we should expect to find no increase in the green or yellow of its spectrum, but only a diminution of the blue and violet colors. The latter was the effect actually observed, and the conclusion drawn from this was further confirmed by observing the spectrum from fluorescing canary glass, in which the green was of course found to be greatly exhausted in brilliancy.

A further confirmation of this idea was obtained by the simple experiment of looking through a layer of these colored liquids at a quinine tube, when exactly the same tint was observed as was given by another illuminated Geissler tube, filled with the solution in question and placed at one side.

I should therefore conclude that the fluorescence of turmeric and of the solution of asphaltum in turpentine is in fact blue, but gets its green appearance simply from the absorptive action of coloring matter present in the liquid. I have of course assumed that in all

these cases there is a large admixture of white light or its equivalent, in the emissions of the blue fluorescing bodies, such as quinine. This is indeed the case, their spectra, as is well known, being practically continuous between the red and lower violet.

Carrying out the idea suggested by the above investigation, it also occurred to me to examine the solution of nitrate of uranium, whose fluorescence has been asserted and denied with such distinctness by various writers. The solid salt introduced into a Geissler tube fluoresces strongly with an actual development of green light, but the solution fluoresces faintly, and with so little green color in its light, compared with the strong yellow tint of the solution, that I should not hesitate to say that its actual fluorescence is blue, like that of quinine, and that it owes its green tinge to absorption.

I feel sure, also, that the same remark applies to agaric and chlorophyle, though I have not yet had time to examine them with the spectroscope, their fluorescence being so faint as to require special arrangements for its study.

I believe, in fact, that the vibrations excited in at least a large class of fluorescent liquids are alike, and are simply composed of a continuous series covering a large part of the spectrum, but with a predominance of the more refrangible rays.

In connection with the above I may here notice another point. As is well known, a neutral solution of quinine sulphate does not fluoresce; an acid must be added. For this purpose, sulphuric, nitric and tartaric acids act well, with doubtless many others; but hydrochloric acid not only does not act, but destroys the action of the others. We can easily assign a chemical reason for the different behavior of the hydrochloric and what we may call the oxygen acids, but, so far as I am aware, the fact does not seem to have been noticed.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaëlis, for the Journal of the Franklin Institute.]

By Adolph Ott.

(Continued from Vol. LXI, page 422.)

The finest and most easily decomposable portions of the mass will then have full chance to enter into the possible combinations with the hydrate of lime during the process of mixing; it is true that

they thus lose their effect upon the hardening of the mortar, which is not of any material importance, however, if we consider the actual surplus of hydraulising matter in all pozzuolana mixtures.

After compressing the mortar into the desired forms, it must be exposed to the air, but great care should be taken to prevent its too rapid desiccation through long insolation or other agencies, in order that the reactions can take place more gradually, more uniformly, and in accordance with the principles laid down.

In destroying the damaging action of the quickly hardening particles, and in thus preventing the solidification at too early a period, and before the less accessible parts can begin to operate upon each other, the coherence of the mass is secured beyond all question.

The fine division of the pozzuolana, the effective mixture obtained by the use of the machine, and the degree of density due to the compression effected by it, will constitute a mortar answering all reasonable expectations.

Under the influence of the carbonic acid of the atmosphere the surface becomes, within a few months, sufficiently dense and indissoluble to enable it to withstand the destructive agencies to which it may be exposed after immersion.

One of the most effective means for the preservation of the mortar is to let it harden, and to protect it against water for some time after its having been made. The ancients already knew this, and Vitruvius considers it imperatively necessary to leave the blocks made out of hydraulic mortar exposed to the air for a considerable lapse of time previous to their immersion (Vitruvius Lib. V. Cap. 12); or to leave them buried underground for a long time, so as not to deprive them of the requisite humidity.

Happily, hydraulic mortars are exposed to the lasting influence of the water of the sea in some instances only; because in most cases testaceous animals, sea plants and mud cover its surface in many places, thus affording a most welcome and effectual protection.

But wherever this cannot be counted upon, nothing should be omitted or neglected which may in any measure contribute to the density and solidity of the surface of the blocks. One of the most effectual means is their repeated spreading over with soluble glass previous to the immersion.

The Beton or Concrete (Signium of the Romans)—foundations below the surface of the sea, etc.—Before giving to the reader some of the numerous directions for the preparation of pozzuolana mortars, it is advisable to speak of the hydraulic aggregate which we shall have to mention repeatedly in the course of this article. We mean the beton or concrete, on the origin, the nature and the importance of which the following remarks will be found appropriate and necessary.

The ancient Romans, for their constructions under the surface of the water, very frequently used a mortar, consisting of common hydraulic mortar mixed with fragments of hard stones or rocks. With this substance, which they called signinum, masonry of any chosen

size or form could be easily constructed. All constructions made with this material may be classed as rough walling with small stones.

Foundations below the surface of the sea were originally constructed by first immersing large rocks or stones, and by then spreading them over with hydraulic mortar, in order to fill up the insterstices between the rocks, and thus to bind them together to one solid mass.

But as it was found extremely difficult to effect an even spreading of the mortar, especially at greater depths of water, the method of mixing the mortar with fragments of rocks previous to its immersion was ere long resorted to, and it was found that a uniformly solid masonry could thus be constructed with comparative ease.

Bélidor says that as the water of the sea is never set into commotion beyond from 4 to 5 meters below the surface, it is most advisable to first immerse small fragments of stones at the bottom, on these larger stones have to be piled up, while the top and the escarpment on the side towards the open sea must consist of the largest possible rocks, which ought to be most carefully laid so as to fit them into one another as much as possible, and bring them into close connexion, for which their irregular form is peculiarly fitted, and may be used with great advantage, provided the work is carefully done. It is advisable to do the work during a calm day, with the aid of skilful divers, who can then plainly discern all objects under the water at a distance of from 2 to 3 meters; and this is exactly the depth at which the water is in the most turbulent commotion, and where, therefore, the greatest precaution ought to be taken. He continues as follows:

"If it is the intention to erect a regular walled mole on such a foundation made of loosely immersed stones, said foundation should reach up to at least 1½ to 2 meters below the surface of the water; the larger stones should then be laid on with the utmost care. The interstices between them should be filled up with smaller fragments, and the structure thus continued until it reaches to within 1 meter below the level of the sea. The work ought then to be discontinued for the period of one year, in order to allow sufficient time, so that by the commotion of the sea a due settling together of the stones will be effected. After this the construction is to be carefully examined to ascertain whether the foundation is settled satisfactorily, when the surface is levelled at about 1 meter below the water.

"In order to be ready for the commencement of the work as soon as a calm sets in, it is necessary to prepare a large quantity of mortar, consisting one-half of gravel or coarse sand and the other half of lime and red earth from pozzuolo. After a careful mixture of these materials a quantity of small flint stones, of the size of walnuts, have to be added.

"This mortar must be left to dry during 24 hours, when, if sufficiently consistent to be handled with a spade, it is put into moulds, the bottom of which can be opened and closed like a lid. These